ANALYSIS OF BARRIERS AND SUCCESS FACTORS AFFECTING THE ADOPTION OF SUSTAINABLE MANAGEMENT OF MUNICIPAL SOLID WASTE IN ABUJA, NIGERIA

by

Chukwunonye Ezeah B.Eng., MSc.

A thesis submitted in fulfilment of the requirements of the University of Wolverhampton for the award of the degree of Doctor of Philosophy (PhD)

MARCH **2010**

Created by C Ezeah

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ABSTRACT

The state of solid waste management in cities of most developing countries is fast assuming the scale of a major social and environmental challenge. In Sub-Saharan Africa in particular, the combined influence of poverty, population growth and rapid urbanization has tended to worsen the situation. The gravity of this problem is perhaps best reflected in the level of attention given to it in the United Nations (UN) Millennium Declaration. Three of the eight Millennium Development Goals (MDGs) outlined in the declaration have waste or resource efficiency implications. In response to the waste challenge many developed countries have embarked upon ambitious environmental reforms, recording remarkable advances in best practises and sustainable management of their Municipal Solid Waste (MSW). However, many developing countries such as Nigeria have fared less well in this regard as a result of several barriers militating against sustainable management of MSW. The principal aim of this research is therefore to carry out a critical analysis of the various barriers as well as success factors that affect the sustainable management of MSW using Abuja, Nigeria, as a case study. The study adopts a largely quantitative methodological approach, employing waste composition analysis of samples from the case study area, questionnaire survey and focus group interviews of stakeholders in MSW management as key methods for generation of data.

Results from analysis of data, using the Statistical Programme for the Social Sciences (SPSS), indicate that between 65-70% of MSW samples from Abuja is biodegradable, mostly comprising of high wet weight and high moisture content kitchen wastes. On the other hand between 11%-30% of MSW samples from the City comprises mostly of non-degradable but recyclable materials such as glass, metals and cans, non-ferrous metals and waste electrical and electronic equipment. The implication of the high levels of moisture content in the biodegradable components is that samples are not suitable for incineration but are ideal for composting and other mechanical and biological management options. Data analysis also reveals that the main barriers to sustainable MSW management in the City include low public awareness/education on MSW management, obsolete and insufficient equipment and funding limitations.

On the other hand, the most important success factor affecting sustainable MSW management in Abuja was found to be the bourgeoning City population which has a huge potential for uptake of recycled products.

In summary, this research concludes that the factors affecting MSW management in Abuja are typical of many tropical urban environments. Fundamental shifts in current practises towards waste prevention; driven by a structured public education programme in MSW management is recommended, so as to bring about a more sustainable management regime. As a result of resource and time limitations, it was not possible to complete several potential lines of investigation related to this study. To fully understand the character of the Abuja waste stream however, further chemical characterization including proximate and ultimate analysis is required. Future research in this genre must endeavour to collect data from a larger sample to increase the precision of the analysis and to enable firmer conclusions to be drawn.

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DEDICATIONS

I joyfully dedicate this thesis to the Almighty God for His faithfulness.

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LIST OF ABBREVIATIONS

AEPB	Abuja Environmental Protection Board
AfDB	African Development Bank
ANOVA	Analysis of Variance
BMW	Biodegradable Municipal Waste
BPEO	Best Practicable Environmental Option
BREW	Business Resource Efficiency and Waste
CBO	Community Based Organizations
CWPC	City Waste Prevention Council
DEFRA	Department for Environment Food and Rural Affairs
DETR	Department of the Environment Transport and Regions
EA UK	Environment Agency, UK
EEC	European Economic Community
EfW	Energy from Waste
EPC	Environmental Protection Council
EU	European Union
FCDA	Federal Capital Development Authority
FCT	Federal Capital Territory
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FGN	Federal Government of Nigeria
GHG	Green House Gases
GLM	General Linear Mode
HHW	Household Hazardous Waste
IPCC	Intergovernmental Panel on Climate Change
KTN	Knowledge Transfer Network
LATS	Landfill Allowance Trading Scheme
MBT	Mechanical Biological Treatment
MDG	Millenium Development Goals
MENR	Ministry of Environment and Natural Resources, Kenya
MRF	Material Recycling Facilities
MSW	Municipal Solid Waste

NEEDS	National Economic Empowerment and Development Strategy
NIMET	Nigerian Meteorological Agency
PCB	Polychlorinated Biphenyls
PCTs	Polchlorinated Terphenyls
PNDC	Provisional National Defence Council
RDA	Regional Development Agencies
SAP	Structural Adjustment Programme
SEPA	State Environmental Protection Agency
SSA	Sub Saharan Africa
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
VO	Voluntary Organizations
WCA	Waste Collection Authorities
WDI	World Development Indicators
WCED	World Commission on Environment and Development
WEEE	Waste Electrical and Electronic Equipment
WIP	Waste Implementation Programme
WRAP	Waste and Resource Action Programme

CHAPTER ONE
INTRODUCTION AND RESEARCH AIMS

1.1: Background of Study

The state of solid waste management in cities of most developing countries is fast assuming the scale of a major social and environmental challenge (Daskalopolous, 1998a). In Sub-Saharan Africa (SSA) in particular, the combined influence of poverty, population growth and rapid urbanization has tended to worsen the situation (Walling *et al.*, 2004). The gravity of this problem is perhaps best reflected in the level of attention given to it in the United Nations (UN) Millennium Declaration (September, 2000). Three of the eight Millennium Development Goals (MDGs) outlined in the declaration have waste or resource efficiency implications (UN, 2007):

- Ensure environmental sustainability by integrating the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.
- Eradicate extreme poverty and hunger by halving between 1990 and 2015, the proportion of people whose income is less than $1 a day.
- Develop a global partnership for development by addressing the special needs of least developed countries, landlocked countries and Small Island Developing States.

In response to the waste challenge many developed countries have embarked upon ambitious environmental reforms, recording remarkable advances in best practises and sustainable management of their Municipal Solid Waste (MSW). However many developing countries such as Nigeria have fared less well in this regard as a result of several barriers militating against sustainable municipal solid waste management (Ezeah *et al.*, 2009a). To illustrate this point, a four country study by the African Development Bank (AfDB, 2002) on Solid Waste Management Options for Africa, revealed the following findings:

1. No country in Africa has detailed solid waste management legislation yet.
2. Solid waste management in most African countries is characterized by inefficient collection methods, insufficient coverage of the collection area and improper disposal of waste.

3. Waste characterization data specific to cities in these countries are generally not available.
4. There is a general lack of regulatory initiatives to manage and minimize waste.

In many ways Nigeria typifies SSA countries with chronic waste management problems. It has a large population of over 140 million people according to census statistics by the Nigerian Population Commission (National Population Commission, 2008). Population growth rate is well above global average at 2.9% per annum. Rapid urbanization and an unevenly distributed wealth occasioned by huge oil income are other factors influencing waste growth in the country (The Economist, 2007). This research is a case study of MSW management in Abuja, Nigeria.

1.1.1: Statement of Problem

Abuja officially became Nigeria's capital in December 1991, following relocation from the former capital Lagos. It is one of Africa's few purpose built cities (Jibril, 2006; BBC, 2007; Adama, 2007). The City was designed to serve as a model to other Nigerian cities in the way utilities and services are managed. Over the last decade, the City has grappled with the challenge of managing its solid waste as a result of phenomenal growths in population and waste generation. It has been reported that the population in some areas in Abuja is growing by as much as 20-30% per annum (World Bank, 2000; Jibril, 2006). MSW management in Abuja is still in its infancy. Institutional and policy frameworks, where they exist, are not in line with global best practises. City specific data on waste necessary for planning are also not readily available (Akoni, 2007). This research was therefore motivated by the need to fill above gaps in knowledge by generating empirically tested data on MSW management in Abuja that could underpin future waste management strategies and policies in the City.

1.1.2: Aims and Objectives

To investigate the above problems, this study has the following aims and objectives:

Overall Aim: Analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Abuja, Nigeria.

Aim 1: Analysis of municipal solid waste arising in Abuja, a major sub-Saharan African municipality representative of developing countries.

Objectives:

a. To survey extensively existing literature on MSW composition and management in SSA.
b. To survey extensively existing literature on the transfer of UK best practises in MSW management to developing countries.
c. To synthesise data on waste arising by observing waste collection and compare location specific data with historical values from the case study area.
d. To carry out a compositional analysis of samples from a representative district of the municipality and at different seasons of the year
e. To locate options available for management and final waste disposal routes.
f. To validate findings by comparing same with historical data held by appropriate authorities.
g. To provide a range of targeted recommendations so as to achieve greater efficiency and cost effectiveness.

Aim 2: Analysis of the barriers and critical success factors necessary to achieve sustainability in the management of MSW in Abuja, a major municipality representative of cities of developing countries with a tropical climate

Objectives:

a. To carry out an extensive literature survey on the barriers and success factors affecting the achievement of sustainable MSW management in sub-Saharan Africa.
b. To review prevailing environmental policies and legal frameworks in Nigeria and compare same with applicable EU/UK legislation.
c. Utilize appropriate social research methods to determine the barriers and success factors affecting the sustainable management of municipal solid waste within the case study area.
d. To assess the barriers affecting sustainable engagement of the informal sector in municipal waste management in Abuja
e. Synthesize, collate and analyse field generated data using appropriate software.

f. To provide a range of targeted recommendations based on empirical evidence from data analysis.

Aim 3: To suggest appropriate legislative and economic drivers to stimulate the uptake of critical performance indicators.

Objectives:

a. To survey literature on legislative and economic drivers of MSW in the UK.
b. To survey existing literature on transfer of drivers from developed to developing socio-economic systems
c. To prescribe changes to current institutional and legislative waste management frameworks, modelled after UK best practise, capable of driving performance at sustainable limits.

1.1.3: Scope and Significance of Study

A detailed description of Abuja, the case study area is as outlined in Section 2.5.1 of this thesis. Though the project study area is restricted to the five districts of Abuja Municipal Area Council: Wuse, Garki, Asokoro, Maitama and Central Area, it is anticipated that the findings and recommendations from this study will have significant basis for application in several other municipalities of SSA.

CHAPTER TWO
LITERATURE REVIEW

This chapter defines the character of solid waste, focusing particularly on MSW in the context of Abuja, a typical tropical urban environment, according to the Nigerian Meteorological Agency (NIMET, 2008a). Trends in MSW management in Nigeria are reviewed, focusing mainly on the key barriers militating against sustainable management practises. Current practises in the United Kingdom have been highlighted as examples of good practise for adaptation.

2.1: Solid Waste

Debate on what constitutes waste is still ongoing within the research community (Read, 2001). Contemporary definitions of solid waste are converging on the essential ingredients of the definition i.e. origin or sources of the material, characteristics and potential to cause harm to the environment.

According to the Department of the Environment (DoE, 1990; DETR, 2000), "waste is any substance which constitute scrap material or an effluent or other unwanted surplus substance arising from the application of a process, or any substance or article which requires to be disposed of as being broken, worn out, contaminated or otherwise spoiled". On the other hand, Igoni *et al*., (2007) viewed waste as, "any material which has no value to the producer and must therefore be disposed of". The basic point of agreement between the two definitions is therefore on the issue of value; they both agree this must be defined by the owner or producer of the waste.

For the purposes of this investigation however, the definition by the EU Framework Directive on Waste (91/156/EEC) has been adopted. The document defines waste as "any substance or object which the holder discards or intends to discard and which falls into one of the following categories:

- Production or consumption residue.
- Product whose date for appropriate use has expired.
- Contaminated or soiled materials.
- Substances that no longer perform satisfactorily" (Europa, 2006).

2.2: Municipal Solid Waste

Municipal Solid Waste, has been defined as household waste and any other waste collected by a Waste Collection Authority (WCA) or its agents, including waste from parks, beaches, commercial establishments, offices, industries and fly tipping (Read, 1999). Other experts insist that MSW include all non-air and sewage emissions created within and collected by private as well as public authorities in any municipality from domestic, commercial and industrial (non-hazardous) sources (Cointreau, 1982; Igoni *et al.*, 2007).

Article 2(b) of the European Union Landfill Directive (EU Landfill Directive, 1999) broadened the definition further by defining MSW as waste arising from households as well as other wastes, which because of their nature and composition are similar to waste from households (EEA, 2003). This implies that MSW may often include biodegradable components such as paper, wood, textiles, food and garden waste, as well as non-degradable fractions such as glass, plastics, tyres and bottles. The various sources of these wastes in any community may include: residential houses, institutions, commercial organizations, municipal services, allotments and treatment sites (Ezeah, 2006). In essence, MSW would normally include all wastes from the neighbourhood except industrial, agricultural and hazardous wastes (Tchobanoglous *et al.*, 1993).

2.3: Overview of Municipal Solid Waste Management in Developing Countries

Globally, MSW generation has continued to increase in line with growth in other socio-economic parameters such as population, personal income and consumption patterns (Sakurai, 1990; Achankeng, 2003; IPCC, 2006).

In the last two decades, per capita waste generation in the developed economies has increased nearly threefold (AfDB, 2002). According to the same study, waste generation in the developing nations is growing rapidly and may double in aggregate volume within this decade, driven largely by growth in population and improvements in living standards. If current trends persist, a fivefold increase in global MSW generation is probable by the year 2025 (AfDB, 2002). The Sub Saharan Africa share of projected growths in MSW generation amongst developing nations is difficult to estimate. It is debatable that the complex relationship between MSW generation,

Green House Gas (GHG) emissions and climate change will affect the region more or less than any other in the world. It is therefore of strategic national and regional importance to establish current MSW situations.

2.3.1: Municipal Solid Waste Management in Sub-Saharan Africa

Until the late 1980s MSW management in most parts of SSA had practically no nationally co-ordinated institutional or policy framework to rest on (AfDB, 2002). Though Municipal Authorities were often required by law to carry out this function, most of them lacked the capacity to do so (Akpofure and Echefu, 2001; Walling *et al.*, 2004). Quite often therefore waste management is very low in their priority list. In the few cases where supervisors were assigned MSW management functions within local authorities, they seldom had the full compliment of qualified staff, such as planners, managers or field and technical staff to work with (Agunwamba, 1998). Since most MSW personnel in these organizations were almost always low cadre staff, they lacked the capacity to influence funding decisions. This often results in severe inadequacies in funding and consequently diminished operational capabilities (Cointreau, 1982; Henry *et al.,* 2006). The consequence is that wastes are quite often dumped at any convenient location by residents and overtime they accumulate into open dumps that have become ubiquitous in many cities in SSA.

Lately, as a result of increasing awareness of the deleterious effects waste has on the environment and positive changes in the socio-economic circumstances of some countries in the region, governments are beginning to put in place policies, programmes and institutions to enhance the management of MSW at all levels (Olowomeye, 1991; Chokor, 1993; IPCC, 2006). To fully understand current MSW characteristics and management practises across the region, a country based-review is necessary in line with key objectives of this research. Consequently, MSW composition and management in four countries representing the major regions of Sub Saharan Africa: South Africa, Kenya, Ghana and Nigeria have been reviewed.

2.3.2: Municipal Solid Waste Management in South Africa

South Africa's premier policy document on integrated pollution and waste management, "White paper on pollution and waste management**"** was published via Government Gazette No. 227 in March 2000. This document encapsulated the overall waste management objectives of the country (South Africa, 1998; AfDB, 2002).

Though the document had a clear strategy for the management of unavoidable waste, the cardinal policy thrust of the document is based on the concept of waste prevention, minimization and resource efficiency.

Before the adoption of this policy document, overall responsibility for the implementation of South Africa's waste policy was scattered amongst several governmental institutions sometimes with conflicting interests and objectives. This piece-meal implementation strategy had often proved counterproductive (AfDB, 2002).

Under the new policy a nationally co-ordinated approach to waste management has been adopted thereby streamlining waste legislation and implementation by various organs of government. As part of this reform the Ministry of Environment with a sub-department, dealing with pollution and waste management, has been created as the apex governmental organization on waste related issues. Equivalent structures now exist in the provinces. Further to these changes South Africa has committed itself to the implementation of an ambitious integrated municipal waste management programme via the Polokwane Declaration in September, 2001 (Polokwane Declaration, 2001).

2.3.3: Municipal Solid Waste Management in Kenya

Overall responsibility for solid waste management in Kenya rests with the Ministry of Environment and Natural Resources (MENR) and the Ministry of Local Government (AfDB, 2002). The main responsibilities of these ministries as regards waste management include: Environmental legislation, policy formulation, monitoring and evaluation, issuance of licences and permits to waste operators and environmental standards enforcement amongst others.

As in most countries, local authorities are primarily charged with the responsibility for waste collection, transfer, resource recovery, recycling and disposal within their jurisdiction in Kenya (Obera and Oyier, 2002). Estimates by USAID and World Resources Institute (WRI) show that these Authorities were only able to collect and dispose of 50-70% of their MSW, spending over 30% of their annual budget in the process in 1992 (Matrix Consultants, 1993).

At present Kenya has no engineered landfills, hence MSW disposal is carried out in open dumps with attendant deleterious environmental consequences. Municipal solid

waste management in Kenya is still very highly centralized with operational decisions often having to wait for senior management in most Council environmental departments. This often results in long delays before the simplest of tasks could be carried out. Lately a few Councils in Kenya have entered into contractual agreement with private waste operators to complement the efforts of Council waste departments (AfDB, 2002).

2.3.4: Municipal Solid Waste Management in Ghana

Ghana typifies most SSA countries with respect to dearth of reliable data on the management of municipal solid waste (Anomanyo, 2004). According to Edoho and Dibie (2000), this situation can hardly be attributed to absence of policy and institutional frameworks. Most possibly, the Ghanaian situation is a result of failure of established frameworks to manage human, physical and financial resources so as to achieve desired objectives. Since independence in 1957, Ghana's environmental policy, like that in most SSA countries has followed European models, with market-friendly, large scale industrial development (Issahaku, 2000). Ghana's regulatory authority, the Environmental Protection Council (EPC) was created in 1974, followed by the enactment of the Provisional National Defence Council (PNDC) Law 116 in 1985, later replaced with PNDC Law 207 of 1988 which made District Assemblies responsible authorities for matters relating to environmental management (Edoho and Dibie, 2000).

Despite the creation of the EPC in 1974 there was no formal procedure for environmental assessment in Ghana until 1994, when the EPC changed into the Environmental Protection Agency through an Act of Parliament. This became necessary with the establishment of a full fledged Ministry of the Environment charged with policy issues at the national level (Ahorttor and Asiamah, 2000). Earlier in 1988, Ghana established its Environmental Action Plan, a policy document that dovetailed into Ghana's Structural Adjustment Programme (SAP) which strongly emphasized sustainability in agriculture, forestry, mining and manufacturing. Despite these strides, core issues bordering on sustainable management of development processes remains largely unaddressed in any concerted manner to date (Issahaku, 2000).

2.4: Municipal Solid Waste Management in Nigeria

Demographic and socio-economic background:

Nigeria is located in the West African sub-region on geographic co-ordinates 10^{o} 00' North of the Equator and 8^{o} 00' East of the Greenwich Meridian. It has a total land area of 910, 768 km^2. The climate varies from equatorial in the south to tropical at the centre and arid Sahel in the extreme north (NIMET, 2008a). Nigeria's official population is put at about 140 million, growing at an estimated 2.9% per annum according to estimates by the National Population Commission of Nigeria (National Population Commission, 2008). Table 2.1 represents Nigeria's population distribution by state and gender according to official 2007 census figures held by the National Population Commission of Nigeria, while Table 2.2 is a summary of demographic and other socio-economic indices in Nigeria. Administratively, Nigeria is divided into 36 states excluding the Federal Capital Territory, Abuja (Adama, 2007). Nigeria exemplifies the chronic solid waste management problems prevalent in most SSA countries, as it grapples with the twin challenges of waste and population growing at rates that are currently unsustainable (Walling *et al.*, 2004).

A primary consequence of this economic dynamic is that often certain proportions of the urban population find themselves unable to afford basic utilities such as water and sanitation. As a result, they resort to self help settling at the fringes of cities in informal settlements often referred to as slums. Such settlements are common features of the urban landscape in sub Saharan Africa (World Bank, 2000; Jibril, 2006).

Nigeria is the most populous country in Africa. Over the past 50 years, it has had the third highest urban growth rate in the world at 5.51% per annum (Walling *et al.*, 2004). Adult literacy is higher than the average in developing countries at about 45%, comparing favourably with other developing nations such as India (57%) and South East Asian countries (56%) according to World Development Indicators (WDI) published by the World Bank (WDI, 2008). Though statistics from the central bank of Nigeria in 2006 put the country's GDP at 176.7 billion US Dollars, growing at an average 8.3%, over 70% of the population still live on less than $1 per day (UNIDO, 2004). The top 2% of the population earned as much income as the bottom 55% in 2000, up from 12% in 1970 (Aboyade, 2004).

It has been argued that this lop sided economic performance is the root cause of the urban slum phenomena in Nigeria as is the case in many other developing nations.

One area where the urban poverty problem has had the most significant impact is in solid waste management (Agunwamba, 1998; Achankeng, 2003).

Table 2.1: Nigerian National Population Census, 2007

State	Persons	Male	Female
ABIA	2, 833,999	1, 434,193	1, 399,806
ABUJA	**1, 405,201**	**740,489**	**664,712**
ADAMAWA	3, 168,101	1606,123	1, 561,978
AKWA-IBOM	3, 920,208	2044,510	1, 875,698
ANAMBRA	4, 182,032	2, 174,641	2, 007,391
BAUCHI	4, 676,465	2, 426,215	2, 250,250
BAYELSA	1, 703,358	902,648	800,710
BENUE	4, 219,244	2, 146,058	2, 055,186
BORNO	4, 151,193	2, 161,157	1, 990,036
CROSS-RIVER	2, 888,966	1, 492,465	1, 396,501
DELTA	4, 098,391	2, 074,306	2, 024,085
EBONYI	2, 173,501	1, 040,984	1, 132,517
EDO	3, 218,332	1, 640,461	1, 577,871
EKITI	2, 384,212	1, 212,609	1, 171,603
ENUGU	3, 257,298	1, 624,202	1, 633,096
KEBBI	3, 238,628	1, 617,498	1, 621,130
IMO	3, 934,899	2, 032,286	1, 902,613
GOMBE	2, 353,879	1, 230,722	1, 123,157
JIGAWA	4, 348,649	2, 215,907	2, 132,742
KADUNA	6, 066,562	3, 112,0282	2, 594,534
KANO	9, 383,682	4, 844,128	4, 539,554
KATSINA	5, 792,578	2, 978,682	2, 813,896
KOGI	3, 278,487	1, 691,737	1, 586,750
KWARA	2, 371,089	1, 220,581	1, 150,508
LAGOS	9, 013,534	4, 678,020	4, 335,514
NASARAWA	1, 863,275	945,556	917,719
NIGER	3, 950,249	2, 032,725	1, 917,524
ONDO	3, 441,024	1, 761,263	1, 679,761
OGUN	3, 728,098	1, 847,243	1, 880,855
OSUN	3, 423,536	1, 740,619	1, 682,917
OYO	5, 591,587	2, 809,840	2, 781,749
PLATEAU	3, 178,712	1, 593,033	1, 585,679
RIVERS	5, 185,400	2, 710,665	2, 474,735
SOKOTO	3, 696,999	1, 872,069	1, 824,930
TARABA	2, 300,736	1, 199,849	1, 100,887
YOBE	2, 321,591	1, 206,003	1, 115,588
ZAMFARA	3, 259,846	1, 630,344	1, 629,502
NIGERIA	**140, 003,542**	**71, 709,859**	**68, 293,683**

Source: (NPC, 2007).

Table 2.2: Nigeria: Summary of demographic and other socio-economic indicators

Population in 1991	88.9 million
Projected Population (2003)	126, 252, 844
Projected male population (2003)	63, 241, 808
Projected female population (2003)	62, 911, 036
Population Growth rate	2.9% per annum
Urban Population	37.7%
Rural Population	62.3%
Totality Fertility Rate	5.7 (NHDS 2003)
Crude Birth Rate	40 per 1000 live birth
Life Expectancy at birth	52 years
Infant Mortality Rate	100/1000 birth
Maternal Mortality Rate	800-1, 500/100, 000 births
Under-five Mortality Rate	210/1000 births
Contraceptive Prevalence Rate	8%
Literacy Rate	45%
HIV/AIDS Prevalence	5%

Source: (NPC, 2007).

2.4.1: Institutional and Policy Frameworks for MSW Management in Nigeria

Municipal solid waste management is rudimentary at best in most Nigerian cities. As a result, gross inefficiencies are common. In some local councils for instance, between 20-50% of their annual budget is said to be spent on municipal waste services, yet such services are available to less than 50% of the urban population (Bartone *et al.*, 1991; Pearce and Kerry, 1994).

According to Adelagan (2004), right from the inception of British rule in the 1900s, colonial economic development policies and plans contained little or no requirements to conserve the natural environment. Thus the formative years of institutional environmental regulation in Nigeria, could be said to have been characterized by the absence of a clear sense of direction and commitment to waste and environmental management. Adama (2007) however disagreed with this position stressing that not

much is documented on MSW in Nigeria prior to colonial administration. The earliest forms of environmental legislation such as the Public Health Act of 1909, the Township Ordinance No. 29 of 1917, as well as the Town and Country Planning Ordinance of 1946, were all introduced by the colonial administration and bear evidence of the emphasis it placed on the environment in general and efficient waste management in particular. In essence the origin of the crisis in MSW management sector in Nigeria has its root in the immediate post colonial era (Adama, 2007).

In 1988, the Federal Government of Nigeria (FGN) established the Federal Environmental Protection Agency (FEPA) in response to the serious challenges posed by environmental degradation, exemplified by the dumping of hazardous waste substances by an unidentified naval vessel around Koko port in the Niger Delta region. The Agency was mandated by the FGN decree 58 of 1988 to among other functions:

(a) Advise the Federal government on national environmental policies and priorities and on scientific and technological activities affecting the environment.
(b) Prepare periodic master plans for the development of environmental science and technology and advise the Federal government on the financial requirements for the implementation of such plans.
(c) Promote co-operation in environmental science and technology with similar bodies in other countries and with international bodies connected with the protection of the environment.
(d) Co-operate with Federal and state ministries, local government councils, statutory bodies and research agencies on matters and facilities relating to environmental protection.
(e) To carry out such other activities as are necessary or expedient for the full discharge of the functions of the agency under this decree (FGN, 1988).

Taking a cue from the Federal government, each of the state governments in the country also established a State Environmental Protection Agency (SEPA) in the mid 1990s. At the local or municipal levels, environmental regulation and management functions were left as before to their individual environmental service departments. In essence, Nigeria like most SSA countries has a three tiered environmental / waste management structure i.e. Federal, state and local environmental authorities.

FEPA was upgraded to a fully fledged environmental department with a cabinet minister at the Federal level in 2000 (Adeoti, 2001), following the coming of a new civilian administration and a result of the rise in profile of the environmental agenda globally. With these institutional reforms, the overall responsibility for environmental regulation and management in Nigeria is currently discharged by the Federal Ministry of Environment, Housing and Urban Development at the Federal level.

Nigeria's premiere policy document on environmental management was launched in November 1989, enunciating guidelines for the achievement of sustainability in fourteen vital sectors including MSW (NEEDS, 2004; UNEP, 2007). This policy document has been lauded by many as a pace setter for other SSA countries to copy. As laudable as this step was, the document soon attracted several criticisms mainly on account of its limited scope and deficiencies in practicality. The policy document was subsequently revised to address those concerns.

With regards to the waste sector, a positive consequence of these developments was the eventual enactment of the harmful waste decree in 1990, providing a legal framework for the management of waste particularly of the hazardous genre. Further to this, as a response to criticisms of the FEPA decree, the government published an amended version in 1992 (Chokor, 1993; Akpofure and Echefu, 2001).

2.4.2: Overview of Municipal Solid Waste Management in Nigeria

Studies have been carried out on aspects of solid waste management in Nigeria. Though few were carried out on a national scale, findings from most of the studies could be applied in the other regions.

A few of the studies with cross regional or national significance are reviewed below:
Adelagan (2004), traced the history of environmental policy and legislation in Nigeria to the earliest days of colonial rule around the early 1900s and posits that the formative years of environmental legislation and management in Nigeria has all along been characterized by absence of clearly laid out objectives and strategies to achieve stated objectives efficiently. Adelagan (2004) contended that there are no clearly formulated policies in Nigeria aimed at co-ordinating and addressing the harmful consequences of industrial development on the environment. The study maintains further that where legislation exists in the country, their enforcement had often been carried out rather poorly.

While it is agreed that existing environmental legislation in the country are poorly enforced, asserting that there is no body of legislation and policies, on which management of environmental concerns may be based, amounts to an over statement. This is because several other studies on the subject agree that inefficiencies in solid waste management in Nigeria cannot be blamed solely on absence of policy and effective legal frameworks (Olowomeye, 1991; Agunwamba, 1998; Walling *et al.*, 2004).

Walling *et al.*, (2004), is one of the few studies on the subject with a national perspective. The study reviews several governmental initiatives at effective and efficient management of MSW in the country, such as FEPA and VISION 2010, and conclude like, Adelagan (2004), that the Federal government currently has very little control over environmental regulation throughout the country. The study maintains further that though Local Governments were intended to fund solid waste management, most have shirked this responsibility as a result of resource inadequacies and endemic corruption in the system. The study sums up the major drivers of the MSW problem in Nigeria as poverty, population growth rate, rapid urbanization and under funding of state agencies.

Other key literature on the subject from the 1990s to early 2000 such as Olowomeye (1991), Agunwamba (1998; 2003), (Onibokun and Kumuyi (1999) in Adama (2007)) as well as Edoho and Dibie (2000) dwelt extensively on the structure and relationships between various state agencies saddled with waste management responsibility and highlights areas of successes and major barriers militating against their efforts at sustainable management of MSW in the country.

While Olowomeye (1991) is of the opinion that many important structures required for the efficient management of MSW in the country are still missing from the Federal through to the local government levels, Agunwamba, Onibokun and Kumuyi argued that current operational difficulties in municipal waste management in the country are reflective of the general state of infrastructural and economic decay in Nigeria. To this extent they argue that any effective solution must be such that take into cognisance the overall economic position of the country. In this respect, they advocate that Government must begin to adopt integrated MSW management solutions that are private sector driven as they have greater potential for long term desirable environmental and economic improvements.

More recent studies on the subject have concentrated on the analysis of the "composition" of MSW in Nigeria, designing local management solutions for its management and situating MSW as an important resource with enormous economic potentials. Igoni (2007), analysed the composition of waste samples from Port Harcourt which is representative of other southern Nigerian cities. This analysis showed that the samples contained 66.6% of volatile solids, 13.5% fixed solids 19.1% liquids and 0.8% other components. This study showed that samples had a carbon: nitrogen ratio of 27:1. These results indicate that samples are ideal for composting as well as having a reasonable potential for energy recovery. The author points out that Port Harcourt, just like most cities in Nigeria, has no engineered landfills. As such, solid waste are most often disposed by burial or simply dumped in open dumps and water bodies.

Similar studies have been undertaken by John *et al.* (2006) for Uyo in South Eastern Nigeria, Kofoworola (2007), for Lagos, South Western Nigeria and for Makurdi, North Central Nigeria by Sha'Ato *et al.* (2007). From their study Sha'Ato *et al*. (2007) showed that approximately 82% of the MSW waste stream from Makurdi comes from households.

2.4.3: Municipal Solid Waste Composition in Nigeria

Estimates of total quantities of MSW generated in Nigeria are difficult to determine. However, estimates of waste generation per capita have been carried out in several investigations (Rushbrook and Pugh, 1999; John *et al.*, 2006; Igoni *et al.*, 2007; Kofoworola, 2007; Sha'Ato *et al.*, 2007). Continued population growth will increase waste growth.

Other parameters studied according to existing literature include moisture content, bulk density and chemical analysis (see Table 2.3). Typical composition of MSW from cities such as Kano, Lagos (see Table 2.4) and Makurdi (see Appendix 2) as presented by (Sha'Ato *et al.*, 2007; Kofoworola, 2007; Igoni *et al.*, 2007), respectively, are equally outlined.

From Rushbrook and Pugh (1999), it can be inferred that variations in the rate of MSW generation and composition could be attributed to changes in the socio-

economic characteristics of the generator community. This implies that socio-economic dynamics affect both the quantity and composition of MSW generated.

Table 2.3: Proximate analysis of organic MSW generated in Port Harcourt, Nigeria

Refuse component	Proximate Analysis (% by weight)			
	Moisture content	Volatile matter	Fixed carbon	Ash
Food waste (mixed)	65.2	26	4.0	4.8
Wood/ Leaves	19.2	65	15	0.8
Paper	6.9	78	9.1	6.0
Plastics	0.3	95	2.4	2.3
Textiles/rubber/leather	7.8	69	16.2	7.0

Source: (Igoni *et al.*, 2007).

Table 2.4: Comparative analysis of MSW composition using samples taken from Kano and Lagos

Component	Kano municipality (%)	Lagos municipality (%)
Paper	17	14
Glass, ceramic	2	3
Metals	5	4
Plastics	4	-
Leather, rubber	-	-
Textiles	7	-
Wood, bones & straw	-	-
Non-food total	**35**	**21**
Food & Putrescibles	43	60
Misc. inert	22	19
Compostable total	65	79
Total	**100**	**100**

Source: (Rushbrook and Pugh, 1999).

2.4.4: MSW Collection in Nigeria.

According to Olowomeye (1991) the collection of solid waste is the most difficult and expensive aspect of solid waste management in developing countries. As a result of the unplanned nature of most cities in Nigeria, this task can sometimes be daunting. Ineffective collection systems often leads to waste accumulation, creating nuisance and odour problems, environmental pollution, fire hazards and generally threatening the physical well-being of the populace.

Survey of existing literature reveals that two primary collection methods are obtainable in Nigeria: “Door to door” and “Depot”, or community disposal, method

2.4.4.1: Door to Door Waste Collection:

Standard waste collection receptacles are rarely available at household level in most parts of sub-Saharan Africa (Boadi and Kuitunen, 2003). In Nigeria particularly, many low and middle income households use whatever container that is readily available, such as baskets, cans, buckets, open drums and sometimes black bin bags for waste collection. As a result of the high organic and moisture contents and high prevailing temperature, waste collected in such sub-standard receptacles decay rather rapidly giving rise to undesirable environmental consequences. In contrast however, most upper income households and government offices use standard receptacles, with covers, for collection of their waste.

Door to door waste collection requires good planning and management. Collection crews come on specified days to empty the bins for transfer to dumpsites. This system demands a minimum outlay of manpower and equipment as well as accessibility. Where these are not readily available the system readily collapses.

2.4.4.2: Depots/Communal Collection Facilities:

In neighbourhoods where access is constrained, waste from households are brought to communal collection facilities sometimes called bring banks. Bring banks may be in the form of skips or other purpose built structures. Collection crews from the local government department or private waste management agencies come on set days to empty the facility. Bring banks are usually centrally located for easy access to the entire community and collection crews. Photo 2.1 shows a typical bring bank in Nyanya area of Abuja. In many cases inadequacies in design and location of bring banks compel some residents to either misuse or not to use bring bank facilities at all, where this happens fly tipping results.

Photo 2.1: Typical bring bank in Nyanya area of Abuja (author's photograph).

2.4.5: MSW Recycling, Transfer and Disposal in Nigeria

2.4.5.1: Resource Recovery/Recycling:

Recycling via resource recovery has huge potentials for economic application especially amongst the urban poor in many developing countries (Bartone *et al.*, 1991; Sakai *et al.*, 1996; Halla and Majani, 1999; AfDB, 2002; Ahmed and Ali, 2004). In Nigeria particularly, several studies exploring MSW recycling practises have been undertaken (Agunwamba, 2003; Afon, 2007; Kofoworola, 2007). The literature reveals that there are several benefits of recycling to the economy and as well as the environment. MSW recycling is at a very rudimentary stage in Nigeria. According to Kofoworola (2007), this is because it has not received much attention from the government; as such, polices and structures regulating the practise for effectiveness are practically non-existent. Presently there is no Material Recovery Facility (MRF) in the whole of Lagos State and the situation is not different in other parts of the country (Kofoworola, 2007).

2.4.5.2: Informal sector MSW Recycling in Nigeria

Despite government's apathy towards resource recovery, economic pressures often force many amongst the urban poor to scavenge waste dumps in Nigerian cities to earn a living (Roberts *et al.*, 2009). In a study on recovery and recycling practises in Lagos, Kofoworola (2007), found out that only materials with high market value such

as paper, plastics, glass and metals were scavenged. In a similar study in three cities in the South Eastern parts of the country (Nsukka, Onitsha and Port Harcourt), Agunwamba (2003), discovered that between 70%-83% of scavengers were unemployed or underemployed urban youths (mostly males). Agunwamba (Agunwamba, 2003) stated further that while most scavengers restrict their activities to open waste dumps and landfills, some prefer to go from house to house and from bin to bin, looking for discarded but useable materials. They are known by different names in different parts of the country: "Mai bottle" in the northern parts and "Baro boys" or "Ndi-ebulu" in the southern parts (Afon, 2007).

In all cases however, materials recovered are either kept for personal use or sold to middle men who further sort them for sale to small scale industries around the City and beyond (see Figure 2.1 below). Agunwamba's study showed that average daily earnings by the scavengers were as high as US $10 in 2003 while middlemen made even much higher profits. In a country where over 60% of the population live on less than $1 a day (World Bank, 2000), such activity poses good prospects for environmental as well as economic sustainability and poverty reduction (UNEP, 2007; UNCED, 2007).

2.4.5.3: MSW Composting in Nigeria:

According to Halla and Majani (1999), municipal solid waste composting reduces the amount of waste and haulage costs while at the same time creating economic and employment opportunities. Traditional Nigerian households made effective use of composting as a management strategy for solid waste generated within their surroundings (Olowomeye, 1991). Olowomeye (1991), recorded that waste generated from households such as yam peels, banana leaves, maize cobs, and egg shells were usually deposited in the backyards where they were allowed to decay for subsequent utilization as manure during the planting season.

Despite this long standing composting tradition, post colonial Nigerian communities have only made limited use of composting as an effective municipal solid waste management strategy. Lewcock (1995), in a survey of farmers use of urban waste in Kano, stated that the huge potentials for compost production in the City has not been exploited as a result of government's apathy in providing the required structures for

this purpose. This same situation is true for many other cities in the country. It is estimated that over 60% of Nigeria's adult population are engaged in agriculture as a

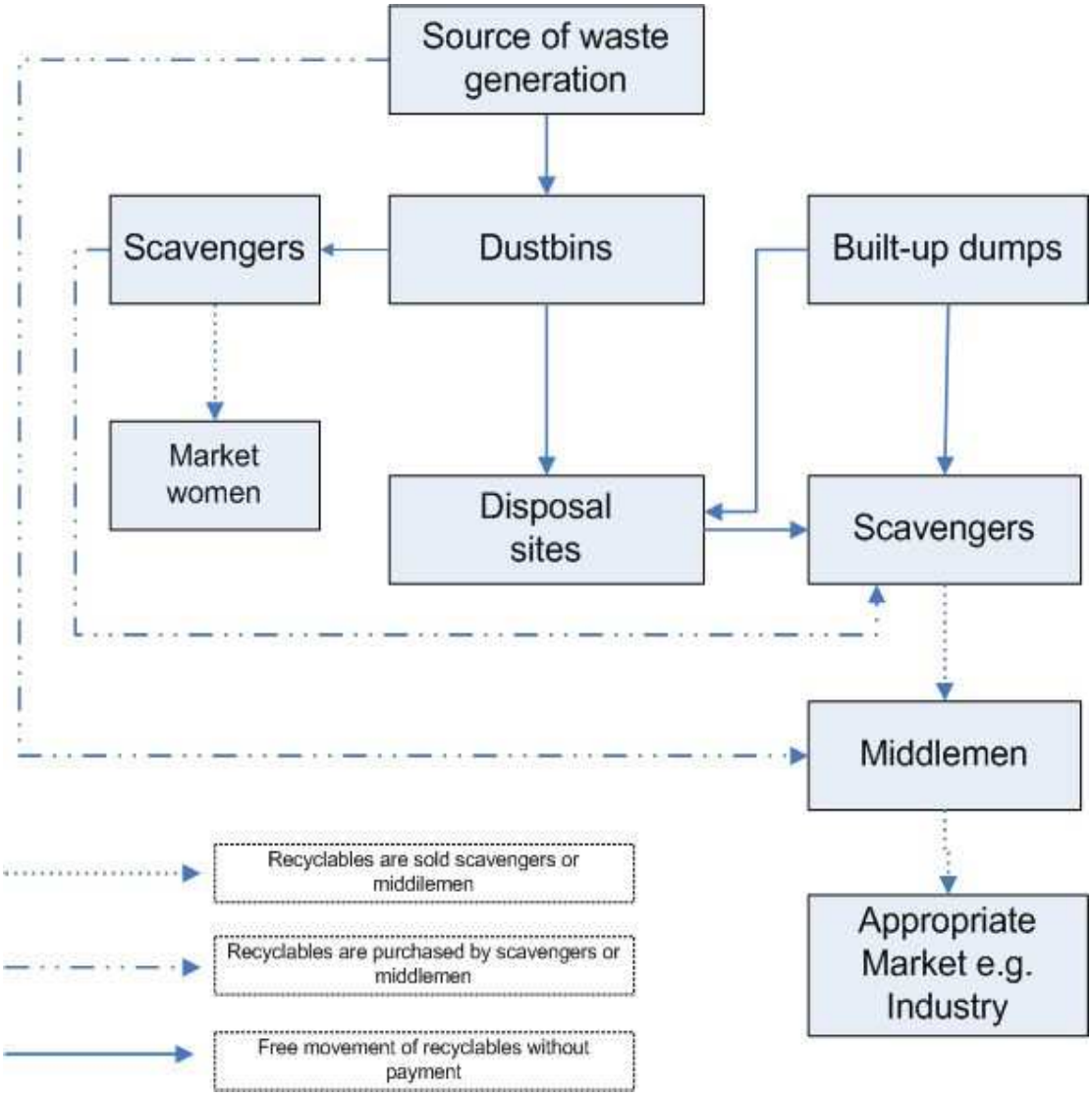

Figure 2.1: Illustration of scavenger activities in MSW management in Nigeria (Agunwamba, 2003).

source of livelihood while the government subsidizes fertilizer importation to the tune of 70% (New-Agriculturist, 2007). Compost production as a waste management option therefore has an added advantage of economic enhancement for Nigeria while at the same time achieving desired environmental sustainability objectives.

2.4.5.4: MSW Transfer and Disposal in Nigeria

There is need to transfer all waste generated from either households or communal facilities in a safe and efficient manner to recycling facilities or final disposal site. Efficient transfer of waste in Nigeria is however difficult due to the peculiar

characteristics of tropical waste streams, terrain and other barriers (Olowomeye, 1991).

In most parts of the country, waste transfer is still carried out haphazardly with wheel barrows, carts, open trucks, lorries, tippers and more recently by compactor trucks (Olowomeye, 1991; Afon, 2007; Coker *et al.*, 2009). As the most common means of transporting waste are open trucks and lorries, it is not uncommon to see street littered with waste dropping from vehicles in transit.

There is need to properly dispose of all collected waste in a safe and sustainable manner so as to avoid any negative environmental and health impacts. Various methods of waste management have evolved over the years such as burning, open dumping, landfilling, composting, incineration, disposal into the sea, pyrolysis, recycling etc (Ezeah, 2006). In the study "Recovery and recycling practises in municipal solid waste management in Lagos, Nigeria", Kofoworola (2007), noted that "the inhabitants of Lagos dump their waste at any location that suits them because there are no defined waste disposal points in the City".

This situation best mirrors the state of waste disposal in Nigeria. Open dumping and burning are still the most prevalent waste disposal methods in the country (see photos 2.2 and 2.3) (Walling *et al.*, 2004).

Photo 2.2: Open waste dump in Nyanya area of Abuja (author's photograph).

The very few landfills that exist in the country are neither engineered nor secured; as a result waste dumped at such dump sites eventually find their way back to block access ways, drainages, farmlands and water bodies (Olowomeye, 1991; Chokor, 1993;

Adelagan, 2004). Photos 2.2 & 2.3 are pictures of open waste dumps in Abuja and Aba, respectively.

Photo 2.3: Open waste dump in Aba (Walling *et al.*, 2004).

2.5: Municipal Solid Waste Management in Abuja

2.5.1: Background

Abuja, Nigeria's capital City since December 1991 is located at the geographical centre of the country approximately at latitude 9° 12' north of the equator and along longitude 7° 11' east of the Greenwich Meridian (Adama, 2007). Abuja has an estimated population of 1.4 million people of which 405,000 live and work within the municipality (National Population Commission, 2008). It has a total land area of approximately 713 km^2 which is divided into six area councils i.e. Abuja Municipal, Abaji, Bwari, Gwagwalada Kuje and Kwali. The climate is generally tropical and it has largely tropical savannah vegetation except for the southern fringes covered by secondary rainforest vegetation. Total annual rainfall in the City averages 1100 mm.

The Government institution responsible for solid waste management in the City is the Abuja Environmental Protection Board (AEPB). The Board's solid waste management portfolio has the following components: City cleaning (concessioned to local contractors in a public private participation arrangement), street sweeping, litter control, solid waste collection and transfer and vegetation control. Garden, hospital and construction waste are managed directly by AEPB (Akoni, 2007).

2.5.2: Abuja Environmental Protection Board

The AEPB was established via the Abuja Environmental Protection Board Decree no. 10 of 1997 with the following aims and objectives:

- Enforcement of all environmental legislation and abatement of all forms of environmental degradation and nuisance.
- Minimisation of the impact of physical development on the ecosystem.
- Preservation, conservation and restoration to pre-impact status of all ecological processes essential for the preservation of biological diversity.
- Protection and improvement of air, water, land, forest, wildlife and ecological quality of the FCT.
- Municipal solid and liquid waste management services including provision of sewer services to properties.
- Pollution control and environmental health services, including fumigation and vector control.

Municipal solid waste management is therefore one of the central mandates of the Board. AEPB solid waste department is responsible for collection, transfer and waste disposal as well as waste material procurements and distribution in the City. Figure 2.2 below is an organogram illustrating the functional departments of the Board.

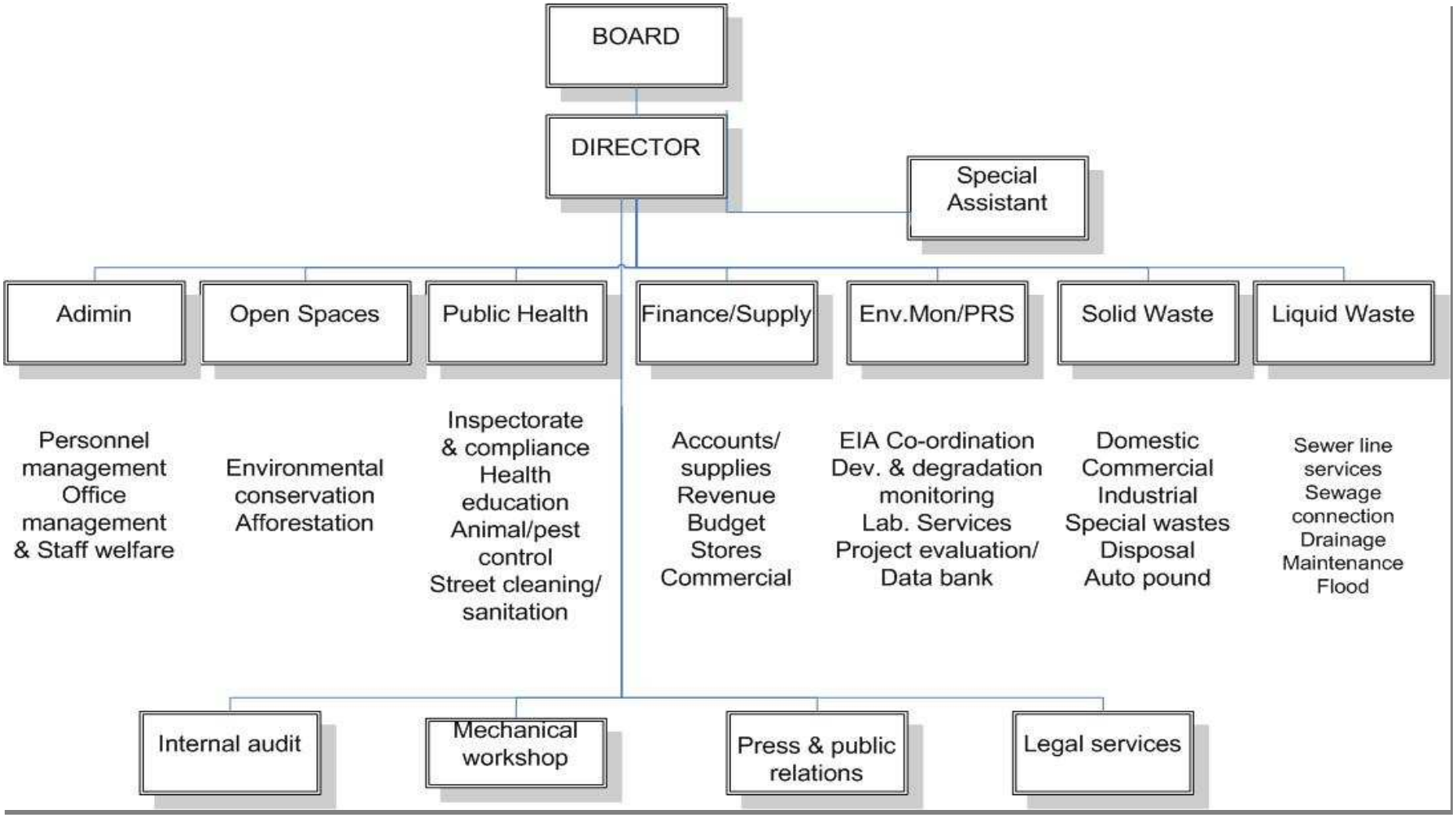

Figure 1.2: AEPB organizational chart (Ezeah *et al.*, 2008).

2.5.3: MSW Generation and Transfer in Abuja

Current the monthly volume of waste sent to landfill in Abuja stands at about 6700 tonnes (Odunfa, 2007). Exact figures or actual quantities of waste generated per capita and per household are difficult to come by but figures from neighbouring cities with similar demographic and socio-economic characteristics such as Accra are put at 0.4 kg per capita and density on a wet weight basis of 0.47 t/m^3 (World Resources Institute, 1998). Figure 2.3 represents projected annual quantities of MSW generation in Abuja (2006-2015). At an estimated growth rate of 3%, the quantity of waste generated from the City will double by 2025 (Ezeah *et al.*, 2009a).

Waste collection from most households and offices within the municipal area is on a door to door basis. At household levels, waste is stored in 240L covered plastic receptacles or black bin bags. For bigger establishments, larger sized receptacles and bring banks are used. Many poorer households, especially those living in the satellite towns and informal settlements at the outer fringes of the City, use any available containers such as baskets and open buckets (which do not meet minimum hygienic conditions) for waste collection before taking them to community bring banks facilities for disposal (BBC, 2007). It is estimated that about 42% of household municipal solid waste collection in Abuja is carried out with flimsy and open containers (Benneh *et al.*, 1993).

Abuja municipality is divided into 13 waste management operational areas. Each of these areas is concessioned to a private sub contractor in a five year Public-Private (PPA) contract arrangement. Within the contract period, all operational responsibility for the given area rests on the sub contractor while the AEPB assumes a supervisory role.

Waste collection from households without any access constraints is carried out on a weekly basis while collection from large organisations and commercial establishments is on daily basis. Equipment used for waste transfer include compacting truck, side loaders, open tippers, pay loaders, roll-on roll-off trucks etc.

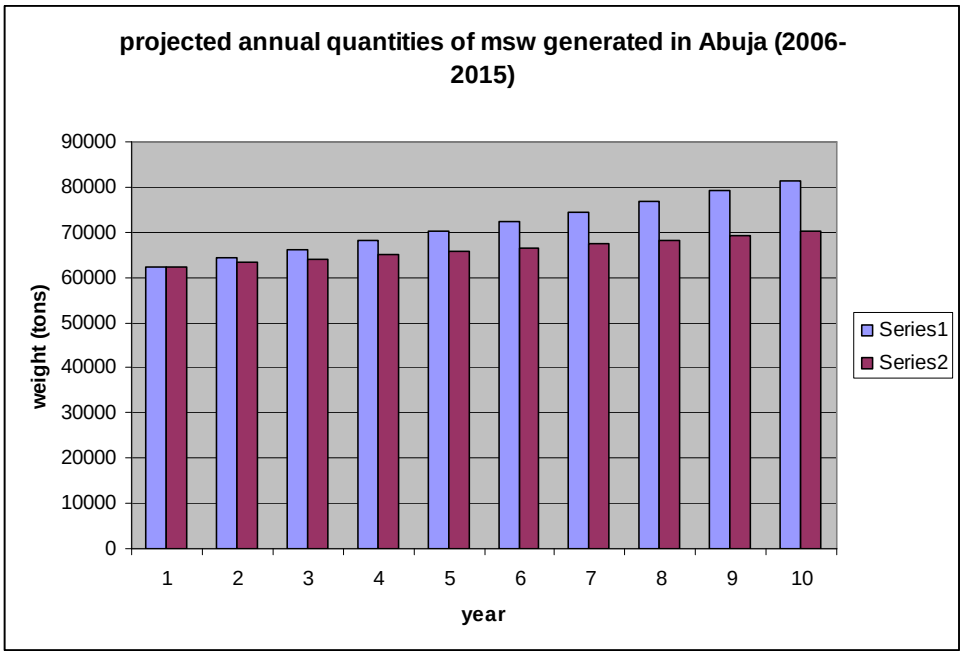

Figure 2.3: Projected annual quantities of MSW generation in Abuja (2006-2015).

2.5.4: MSW Composition in Abuja

There are scarcely any published studies on the characteristics and composition of the municipal solid waste stream from Abuja (Adama, 2007; Imam *et al.*, 2008). AEPB is said to have carried out several analyses of the composition of waste samples from the City. Few such studies were however made available to the author. Such absence of reliable data is a serious barrier to designing an efficient and sustainable MSW management strategy for the City. Figure 2.4 illustrates results of a survey carried by the AEPB in 2001 to ascertain the essential composition of MSW waste streams from the City. Though this study is quite useful being the oldest survey on record, its significance is limited by the scanty background information of the survey. For instance, the exact sources of the samples are not known. Neither is it clear what time of the year the survey was carried out.

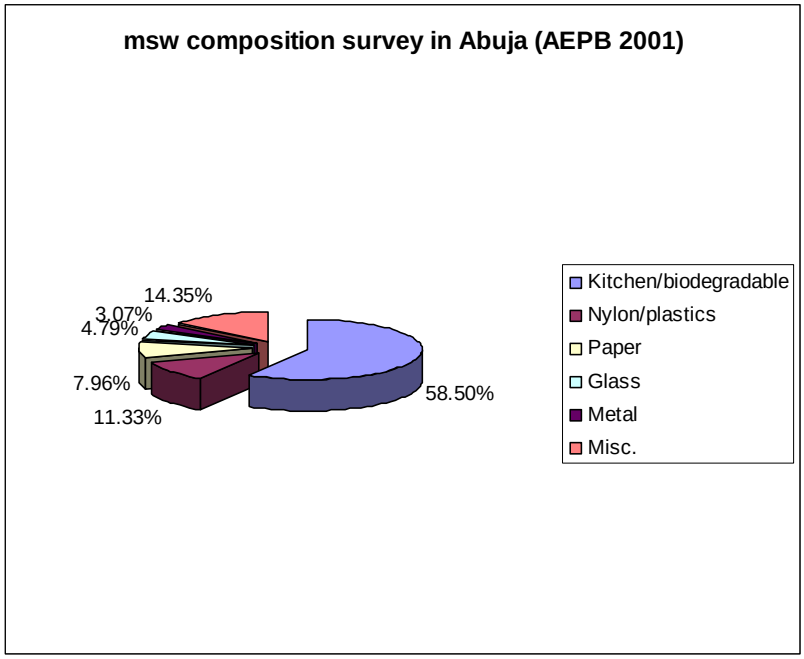

Figure 2.4: Municipal solid waste composition in Abuja (2001).

From Figure 2.4, total biodegradable component of the waste stream is 66.46%. Nylon and plastics make up 11.33% of the stream while glass, metals and miscellaneous substances make up 4.79%, 3.07% and 14.35%, respectively. These results are similar to those obtained by Sha' Ato *et al.*, (2007) for Makurdi, another north central City located about 300 km away from Abuja.

2.5.5: MSW Recycling, Composting and Disposal in Abuja

At present, there is no strategy or formal recycling programmes for the City of Abuja. No material recovery facility exists in the City. Consequently, materials re-use and recycling activities throughout the municipality are limited to household reuse and scavenging activities of the urban poor (Akoni, 2007).

According to Boadi and Kuitunen (2003), "waste recycling at households in low income areas begin with the re-use of plastics, bottles, paper, cardboards and cans for domestic purposes. These materials are disposed of only when they are no longer of any use to their owners". Elsewhere, including high income neighbourhoods, scavengers directly take out valuable items such as metals, paper and plastics from refuse bins and dumps or buy them from domestic helps for resale to middlemen. At dumpsites, community bring banks and even directly from waste disposal vehicles still on transit, these scavengers can be seen picking out items considered valuable by them to be for reuse or sale.

Agunwamba (2003) outlined the economic benefits of scavenging activities in Nigeria to include employment opportunities and income generation. These benefits he cautions must be viewed side by side with potential health hazards posed to individual scavengers and the community at large.

Organic or bio-degradable waste components are not usually picked by scavengers in Abuja. According to Lewcock (1995) and Mbeng (2009), the presence of certain drivers aid the valorisation of organic waste streams as compost in the tropics. Critical amongst such drivers are the existence of a thriving urban farming culture and an enabling policy /institutional environmental framework to enhance composting and its usage. Given that Abuja is indeed a new City, these factors do not yet exist. This therefore may partly explain the disinterest of scavengers in the biodegradable components of the waste stream in the City. Odunfa (2007) posits that presently a negligible percentage of the municipal waste stream in Abuja is recovered through the recycling and reuse activities of the informal sector workers. The failure of resource recovery implies that presently, nearly the entire waste stream in the City has to be disposed off at dump sites. Current waste disposal methods in the City are limited to burning and open dumping since there are no engineered, or sanitary, landfills within the City. All waste collected is taken to the Gosa solid waste dump site in the Idu Industrial Layout for disposal (Odunfa, 2007). Figure 2.5 is a comparative analysis of MSW disposed at dumpsites in Abuja (2005-2007). Open dumping is a very unsustainable disposal method, as a result of the adverse environmental impacts (Boadi and Kuitunen, 2003).

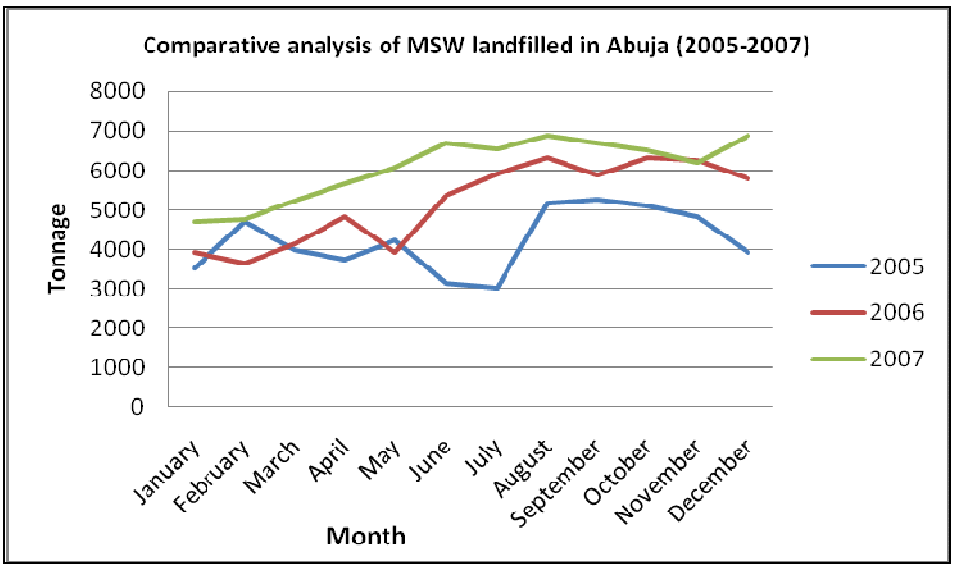

Figure 2.5: Comparative analysis of MSW disposed at dumpsites in Abuja (2005-2007) [based on data from AEPB].

2.6: Municipal Solid Waste Management in the United Kingdom

There are four waste management strategies in the UK. England, Wales, Scotland, and Northern Ireland have each developed a National Waste Strategy outlining ways of dealing with waste generated within their jurisdiction. The 'National Waste Strategy 2007 - England' (Defra, 2007) described the vision for managing waste and resources and sets out the changes needed to deliver more sustainable development in England. Where appropriate, this document will be used as the basis for comparison and illustration of best practise in the UK.

2.6.1: Overview of MSW Composition and Management in England

The growing profile of municipal solid waste management in England is best mirrored by the level of activity generated within the sector in the past decade. Within this period, there have been three strategy consultation documents, two waste strategies, and a plethora of implementation programmes in response to European Directives (Audit Commission, 1997; Read, 2001)

Since the publication of the Waste Strategy for England and Wales 2000, significant progress has been recorded particularly in England. In absolute terms, waste growth is reducing, growing slightly slower than the economy by 0.5% per year (Defra, 2007). Average percentage of total MSW landfilled has equally reduced from 78% in 2000/01 to 65% in 2005/06. During the same period, average recycling rate has grown fourfold to 25% in 2005/06 while recycling of packaging waste increased from 27% to 56% in the same period (Defra, 2007). Drivers that helped achieve these significant growths include changes in policy, such as the Landfill tax escalator, the introduction of the Landfill Allowance Trading Scheme (LATS), additional funding for Local Authorities, rigorous implementation of EU wide directives and targets on specific waste sectors such as vehicles, Waste Electrical Electronic Equipments (WEEE) and packaging. Other delivery structures that have equally facilitated recent growths include: the Waste Implementation Programme (WIP), the Waste and Resource Action Programme (WRAP) and the Business Resource Efficiency and Waste (BREW) programme (Defra, 2007).

As in most countries, MSW management in England is a shared responsibility. While the Environment Agency holds overall responsibilities for environmental regulation, County Councils have the function of Waste Disposal Authorities. Within a County, the District or Borough Councils serve as Waste Collection Authorities dealing with the collection and

transportation of MSW. In the case of Unitary Authorities, the functions of the Disposal and Collection Authority are combined under one layer of local government rather than the more common two-tier approach (Phillips *et al.*, 1999).

In many cases certain levels of regional organizations and/or quasi-governmental structures exist, facilitating effective service delivery (Read, 1999). The white paper "Making Waste Work" marked the paradigm shift in MSW management in the England (DoE, 1995). The White Paper fundamentally re-focused the national psyche on the imperatives of more sustainable approach for waste management in line with the Bruntland Report (WCED, 1987). Since then, two other strategy documents i.e. Waste Strategy for England and Wales (DETR, 2000) and Waste Strategy for England (2007) have been published outlining the essential composition of municipal waste arising in England while at the same time road mapping the overall national MSW management objectives. Figure 2.6 below is a compositional analysis of household waste conducted by WRAP in 2000/01.

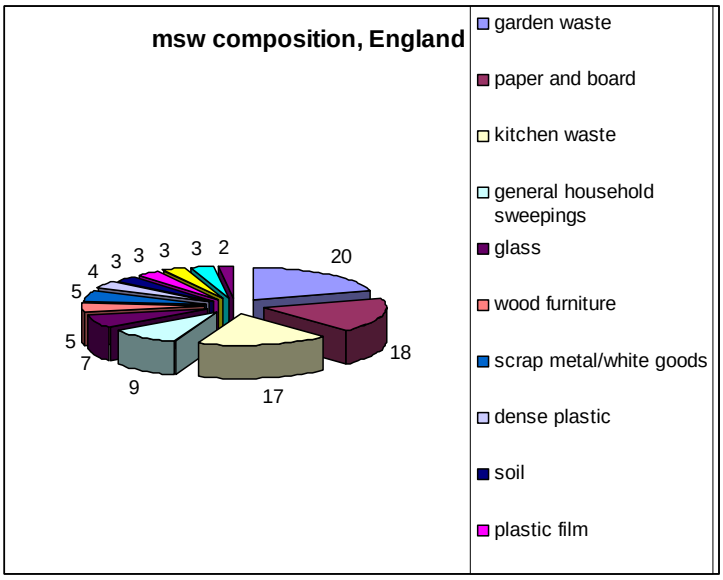

Figure 2.6: Household waste composition, England (2000/01) (WRAP, 2008).

2.6.2: Waste Management Strategies and Policy Objectives in England

Though significant progress has been made since the publication of Waste Strategy 2000, the UK's overall performance continues to lag behind many mainland European nations (Defra, 2008a). For instance, of the 27.3 million tonnes of MSW produced in England in 2008/09, 50.3% was sent to the landfill compared with 37% in France, 18% in Germany and less than 3% in The Netherlands (Defra, 2010). UK central government targets reducing the quantity

of waste sent to landfills. The realization of this target is hinged on making waste management a shared responsibility for every section of society (Defra, 2007):

- ●Producers will seek to redesign their production processes with the aim of making products that are less wasteful and take responsibility for adverse environmental impacts of their products throughout the product's life. Producers to aim at using more recycled materials and less new extracted raw materials as industry best practise.
- ●Retailers will have to reduce packaging, prefer to market products from eco-friendly producers and educate their customers to choose likewise.
- ●Consumers – Businesses as well as households to seek all avenues to generate less waste, separate their waste at source for easy recycling thereby lessening adverse environmental impacts.
- ●Local authorities to provide residents with adequate education on how to reduce waste and provide convenient and sustainable waste management options for unavoidable waste.
- ●Waste management industry to access and invest in new technologies that emphasize waste avoidance and re-use while providing convenient service options for their customers where waste production is unavoidable.
- ●Central government will provide the enabling environment for all stakeholders in waste/resource management to take responsibility and show leadership through appropriate actions for sustainable waste management (Defra, 2007).

In line with the above vision statement, Waste Strategy (2007) outlined the following immediate and strategic objectives as it concerns municipal solid waste management in England:

1. To decouple waste growth (in all sectors) from economic growth by putting greater emphasis on waste prevention and re-use.
2. To meet and exceed the Landfill Directive diversion target for biodegradable municipal waste in 2010, 2013 and 2020.
3. Secure the investment in infrastructure needed to divert waste from landfill.
4. To achieve optimal environmental benefits from investments through increased recycling of resources and energy recovery, using a mix of technologies.

2.6.3: MSW Management Infrastructure and Support Organizations in England

1. DEFRA

The Department for Environment Food and Rural Affairs (DEFRA) is the apex Government Department responsible for waste and related environmental issues. Working either through internal structures, such as WIP or external organizations such as WRAP, BREW and other third sector organizations, DEFRA co-ordinates efforts aimed at achievement of the overall objectives of government's waste strategy as encapsulated by Waste Strategy (2007).

2. WRAP

The Waste and Resources Action Programme is a not for profit organization created by government in 2000 as a one stop shop to work in partnership with other waste sector organizations, businesses and consumers to deliver greater material and resource efficiency through recycling more things more often (WRAP, 2008).

3. BREW

Following a £3 per tonne increase in landfill tax by Her Majesty's Treasury for the year 2005/6 (currently at £48 per tonne in 2010), it became necessary to utilize the additional revenues generated to fund programmes that could support improvements in resource efficiency, especially in waste minimization and diversion from landfill (Defra, 2008a). The Business Resource Efficiency and Waste (BREW) is a package of programmes designed by Defra in partnership with business stakeholder to enhance resource efficiency. Through this programme, businesses are incentivised to reduce the amount of waste they send to the landfills. Projects funded by BREW are delivered through established programmes and organizations such as WRAP, Resource Efficiency and Knowledge Transfer Network (KTN), Regional Development Agencies, (RDAs), Waste Matters etc.

4. WIP

The Waste Implementation Programme WIP was set up in June 2003 by the Department of Environment Food and Rural Affairs (Defra, 2008a). WIP was conceived to respond to the need to reduce municipal waste (especially Biodegradable Municipal Waste, BMW) sent to the landfill by providing adequate support to bring about waste reduction, reuse and recycling. The objective is to help England meet binding targets under Article Five of the EU Landfill Directives. Precisely, these targets are:

- By 2010 to reduce biodegradable municipal waste landfilled to 75% of that produced in 1995.

- By 2013 to reduce biodegradable municipal waste landfilled to 50% of that produced in 1995.
- By 2020 to reduce biodegradable municipal waste landfilled to 35% of that produced in 1995 (Defra, 2008a).

The measures designed by WIP to realise the above objectives include: Local Authority support, Local Authority funding, research funding for new technologies, data and information management, waste infrastructure delivery programme, efficiency initiatives, waste minimization programme, kerbside and waste awareness programme (Defra, 2008a).

Third Sector Organizations

The "Third Sector" is a loose term currently used to refer to a range of value-driven, largely non-governmental organizations working in waste in England such as Community Based Organizations (CBOs), Voluntary Organizations (VOs), charities, co-operatives, social enterprises etc. It is estimated that over 1000 third sector organizations are currently involved in waste management in England alone (Defra, 2008a). Third sector organizations often have areas of expertise of individual strengths that are quite productive when channelled towards areas of need in waste management, such as attitudinal change programmes, recycling campaigns etc (Defra, 2008a).

2.6.4: Waste Policy and Regulatory Frameworks in England

The legislative framework and policy instruments for sustainable waste management in England are continually evolving (Defra, 2007). However the essential thrust remains the same, in that all national and local waste policies and strategies are targeted towards realising the objectives of the EU Framework Directives on waste. This implies therefore that waste laws, policies and strategies in England and Wales are developing concurrently at three separate levels:

- European legislation.
- National legislation.
- Regional/local legislation.

2.6.5: European Legislation on Waste

Waste Framework Directive 75/442/EEC as amended

This is the precursor to all EU legislation on Waste (Europa, 2006). The Directive lays out broad guidelines on waste management aimed at the protection of the environment from

harmful effects caused by improper collection, transport, storage and disposal methods. Particularly, the Waste Framework Directive is aimed at encouraging member states in the recovery and reuse of wealth from waste in other to conserve natural resources. The Directive also establishes requirements for licensing, and regulation of carriers as well as the polluter pays principle. This Directive has since been amended by EU Directives 91/156/EEC and 91/92/EEC. The provisions contained in the Framework Directive were implemented into law in England and Wales by the Environmental Protection Act (1990), as amended by the Environment Act (1995), together with a number of regulations on various aspects of waste management (DETR, 2000). In April 2006, Directive 75/442/EEC was again amended by the European Parliament and Council to further consolidate, clarify and rationalize the legislation. The amended legislation, Directive 2006/12/EC do not however change existing rules in the member states (Europa, 2006).

2.6.6: Other European Legislation on Municipal Solid Waste Management and Related Matters Applicable in England

Directive 89/369/EEC-Prevention of air pollution from waste incinerators.

Directive 89/429/EEC- Prevention of air pollution from waste incinerators.

Directive 90/425/EEC-Animal Waste.

Directive 90/667/EEC- Animal Waste.

Directive 91/689/EEC-Urban wastewater treatment.

Directive 91/692/EEC-Standardizing and rationalizing reports on the implementation of certain environmental directives.

Directive 94/31/EEC-Hazardous waste.

Directive 96/59/EEC-Disposal of Polychlorinated biphenyls.

Directive 96/61/EEC-Intergrated pollution prevention control.

Directive 99/31/EEC-Landfill.

Decision 96/350/EC- Waste.

Decision 96/129/EC-Packaging and packing waste (DETR, 2000).

2.6.7: Waste Legislation in England

According to Waste Strategy 2000, "Legislation and policies governing waste handling and disposal in England have evolved remarkably in the past 30 years. The principal aim is to constantly bring prevailing legislation in the country in agreement with governing European

Union laws and policy directives". The following main and auxiliary legislation currently guide waste management in England:

Control of Pollution Act, (1974).

Local Government Act, (1985).

Control of Pollution (Amendment) Act, (1989).

Environment Protection Act, (1990).

Town and Country Planning Act, (1990).

Planning and Compensation Act, (1991).

Environment Act, (1995).

Finance Act, (1996).

Merchant Shipping and Maritime Security Act, (1997).

Town and Country Planning General Development Order, 1988, SI 1813 Controlled Waste. (registration of carriers and seizure of vehicles) Regulation 1991, SI 1624.

Environmental Protection (duty of care) Regulations, 1991, SI 426.

Waste Management Licensing Regulations, 1994, SI 1056 as amended.

Town and Country Planning (general permitted development) Order 1995, SI 418.

Town and Country Planning (general development procedure) Order 1995, SI 419.

Special Waste Regulations 1996, SI 972 (as amended).

Chemicals (hazard information and packaging for supply) Regulation, 1996.

Producer Responsibility Obligations (packaging waste) Regulations 1997, SI 648.

Packaging (essential requirements) Regulations 1988, SI 1165 (DETR, 2000).

2.7: Best Practises in MSW Management in England

Sustainable MSW management become a key issue in the UK immediately after the Earth Summit in Rio de Janeiro in 1992 (Phillips *et al.*, 1999). This radical shift towards sustainable waste management became necessary given the unacceptable levels of inefficiencies in the system. For instance, it is the opinion of Phillips *et al.*, (2001) that for every tonne of useful product made in the UK, 10 tonnes of other resources were consumed. Best practise in waste management seeks to reduce the amount of waste produced as well as reduce the environmental impact of unavoidable or residual waste (Coggins, 2001).

In the UK, municipal solid waste management best practises are premised upon three fundamental principles. Phillips *et al*., (2001) outlined these as:

1. Best Practicable Environmental Option (BPEO). The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefits or the least damage to the environment, at acceptable cost, in the short as well as the long term.

2. The Waste Hierarchy. The waste hierarchy is a conceptual framework which acts as a guide to the options which should be considered when assessing BPEO.

3. The Proximity Principle. This principle holds that waste should be disposed of as near to its place of production as possible.

From the foregoing, it is established that the central focus of all waste strategies in the UK is based upon a hierarchy of preferred options to deal with waste as reflected in Figure 2.7.

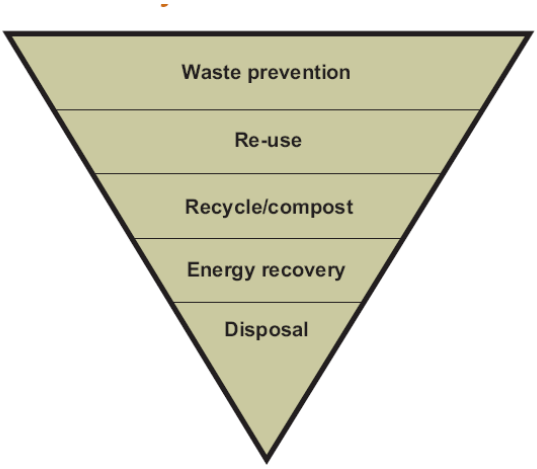

Figure 2.7: Municipal solid waste management hierarchy (Defra, 2008a).

2.7.1: Waste Minimization/Prevention in England

Pratt and Philips (2000) hold the view that there is no single definition of the term waste minimization. However, Read *et al.* (1997) adopted a broad US definition of waste minimization as "prevention and/or reducing the generation of waste, improving the quality of waste generated, including reduction of hazard and encouraging re-use, recycling and recovery". This, they insist is the key to sustainable waste management in the UK. From the foregoing, it is germane that waste minimization programmes are much more than re-use or recycling developments. They concentrate upon resource efficiency and waste reduction and by this, increase the production of more first class products per unit of resource (Phillips *et al.*, 2006).

Waste minimization is at the top of UK's hierarchy of preferred management options. Several policy initiatives and strategies have been introduced to encourage the uptake of waste minimization methodology by industry (Pratt and Phillips, 2000; Defra, 2007). Such

initiatives as waste minimization clubs have been reported extensively by literature (Clarkson *et al.*, 2002; Phillips *et al.*, 2003; Phillips *et al.*, 2004).

2.7.2: MSW Recycling and Composting in England

The obligation from the EU Landfill Directive is for England to reduce the landfilling of the biodegradable components of municipal solid waste arising to 75% of 1995 levels by 2010, 50% by 2013 and 35% by 2020. Failure to meet these targets exposes the England to possibilities of non-compliance fines of up to £500,000 per day after 2010. This cost will be borne ultimately by Local Authorities (Karousakis and Birol, 2008). If these targets were to be realised, significant changes in current MSW management practise are required (Price, 2001). Defra (2005) has already determined that 60% of England's municipal waste stream is BMW. This implies that apart from waste minimization, recycling and composting equally promise great potentials for achieving stated mandatory Landfill Directives and targets (McDonald and Oates, 2003; Tonglet *et al.*, 2004a).

National averages for recycling/composting in 2003/04 was 17% as against (25%) expectation (Defra, 2008a). By 2007/08 however, some of the best performing Local Authorities were already recycling/composting over 58% (as against a national target of 40% by 2010) of their municipal waste stream; these figures compare favourably with figures from best performing European nations such as Austria (69%) and Germany (65%) (Europa, 2008). These significant growths in recycling have largely been achieved through the interplay of a basket of economic and legislative drivers (Coggins, 2001; McDonald and Oates, 2003; Tonglet *et al.*, 2004a). Other factors that have facilitated recent growth in recycling and composting include the continued optimization of several delivery structures established in the last decade, or there about, increased funding and a noticeable shift in public attitude towards pro- environmental behaviour as a result of sustained public education programmes by agencies such as Defra, WRAP etc. (Tonglet *et al.*, 2004a).

2.7.3: Energy Recovery

Municipal solid waste incineration for purposes of energy recovery is a mid table option in the hierarchy of waste management options. Ideally, it is a complementary option in an integrated management model, where waste prevention/ minimization sits atop and landfilling (without resource recovery) takes the bottom of the table of disposal options.

In terms of its current status, waste incineration / energy from waste (EfW) accounted for 10% of the overall volume of MSW produced in England in 2007/08, which equals approximately 2.8 million tonnes per annum. Overall, the UK has 19 incineration plants in operation, processing MSW with individual annual operating capacity in terms of waste consumption, varying between 23,000 tonnes to 600,000 tonnes (Defra, 2008b). Comparatively, the use of incineration as an MSW management option in the UK is still low as against other EU nations, such as France (32%), Sweden (52%) and Denmark (55%) (Defra, 2007). However, further deployment of incinerators is being considered while at least four more plants are nearing commissioning (Waste Strategy, 2007; Defra, 2008b).

2.7.4: Best Practise Drivers in England

Waste is the most visible face of inefficiency in any system. Waste reduction therefore implies increasing systemic efficiencies. This however depends on the level of compliance to globally accepted waste management best practises. Several schemes based on economic, regulatory/legislative and incentive instruments have been used in Europe to drive optimal performance in municipal solid waste management (Husaini *et al.*, 2007).

2.7.4.1: Regulatory/Legislative Drivers

English Government has set challenging but realistic targets to increase efficiencies in the management of its MSW (Read *et al.*; Mee *et al.*, 2004; Read *et al.*, 2009). These targets include:

-Recycling and composting of household waste – at least 40% by 2010, 45% by 2015 and 50% by 2020.
-Recovery of municipal waste – 53% by 2010, 67% by 2015 and 75% by 2020.

Additionally the EU Landfill Directive (Tonglet *et al.*, 2004a) seeks to limit:
-By 2010 no more than 75% of total BMW produced in 1995 to be landfilled.
-By 2013 no more than 50% of total of BMW produced in 1995 to be landfilled.
Consequently significant progress has been achieved driven mostly by changes in policy designed to achieve above listed targets. The landfill tax escalator and the introduction of the Landfill Allowance Trading Scheme (LATS) have yielded much needed incentives to divert waste from landfills (Mee *et al.*, 2004; Phillips *et al.*, 1998).

2.7.4.2: Economic Drivers

These refer to schemes or mechanisms put in place to achieve the objectives of the polluter pays principle (Read *et al.*, 2009). What constitutes drivers vary from one local authority to another. In practise they are all variants of the variable charging scheme for waste services delivered by local authorities. Specifically drivers may be implemented as unit based, weight-based or volume based charging schemes. In any variant of the scheme, the amount paid is proportional to the waste thrown away (Husaini *et al.*, 2007). To pay less, waste generators would have to minimize the amount of waste generated. A few local authorities in England are currently pilot testing the application of such schemes to drive their waste prevention and recycling campaigns (Mazzanti and Zoboli, 2008; Phillips *et al.*, 2002).

2.7.4.3: Incentive Based Drivers

These are schemes designed by local authorities to provide some level of financial or other assistance to encourage waste prevention or pro-environmental behaviours. These may take the form of full or partial underwriting of the cost of waste services. Alternatively they may be provided as material based incentive schemes whereby essential waste management consumables are provided to waste producers at subsidized costs to encourage them to achieve set targets in recycling, composting etc. (Husaini *et al.*, 2007).

2.7.5: Best Practise transfer from UK to Developing Socio Economic Settings

Efficient management of MSW has several aspects, political, socio-economic, environmental and technical. In principle however, the objectives of MSW best practises remain the same from country to country (Rushbrook and Finnecy, 1988). Waste Strategy 2007 for England (Defra, 2007) reports that since the publication of the waste strategy in 2000 (DETR, 2000), England has made significant progress in the adoption of sustainable practises for municipal solid waste management (Read *et al.*; Read *et al.*, 2009). During this period, a range of globally accepted waste management best practises have been developed within the UK.

Studies have suggested that successful waste management best practise developed in the western parts of the world could be transferred with modifications to achieve similar results elsewhere in the developing regions of the world (Barton *et al.*, 2008; Matete and Trois, 2008; van der Gaast *et al.*, 2009). Barton (2008), however, is of the view that in considering waste options which might be suitable for developing countries, certain options such as

energy from waste needs to be discounted as a result of certain barriers militating against their adoption. Some of these barriers may include:

- The characteristics of the waste (they are often high in organics and not suitable for incineration).
- Generally developing countries lack the level of technical support which could be required for certain sophisticated incineration options.
- There is a general absence of trained manpower and other necessary infrastructure.
- Financial capacity of most developing countries is rather low to support expensive waste management schemes.

Bearing in mind therefore the issues of choice and appropriateness of technology (Rushbrook and Finnecy, 1988), certain best practise options developed in the UK have been suggested for adaptation in developing countries such as Nigeria, based on the findings of earlier investigations on the subject (Phillips *et al.*, 1999; Thomas, 1999; Barton *et al.*, 2008). Suggested options include:

- Options for landfill (passive venting, gas capture with flaring and gas capture with energy production.
- Waste minimization / waste prevention.
- Recycling/composting.
- Anaerobic digestion with electricity production and composting of digestate.

According to Thomas (1999), technological appropriateness is not an intrinsic quality of any technology but is derived from the operating domain in which it is to be utilized. There is therefore an implied necessity for flexibility in making decisions about what best practise is ideal since experience suggests that adaptation is often a process that evolves over time.

2.7.6: Transfer of Drivers from UK to Developing Socio Economic Settings

Phillips *et al.*, (2002) has identified the main drivers of municipal solid waste management best practise in the UK. According to Phillips, they include policies and legislation, efficient waste institutions, socio-economic factors, education and public awareness as well as various regulatory frameworks established over time at both government and non-governmental levels. Husaini *et al.*, (2007) and van der Gaast *et al.*, (2009) have also discussed the various barriers that could hinder the transfer of drivers from one socio-economic setting to another. Therefore, according to (Wilson, 2007), attainment of the level of efficiencies currently achieved in the UK by developing countries such as Nigeria will largely depend on their

capacity to adapt proved drivers from the UK as summarized in Table 2.5 to suite their local conditions and circumstances.

Table 2.5: Summary of MSW best practise drivers employed in the UK

Institutional drivers of MSW best practise	• Environment Agency (EA) • Department of Environment, Food and Rural Affairs (DEFRA) • Waste Implementation Programme (WIP) • Business Resource Efficiency and Waste (BREW) • Waste and Resource Action Programme (WRAP) • Knowledge Transfer Networks (KTN) • Waste Collection Authorities (WCA) • Waste Disposal Authorities (WDA)
Socio economic drivers	Variable charging schemes for council waste services e.g. o Weight based charging schemes o Weight and volume based charging schemes o Tagged bag schemes o Environmental levy on use of plastic bags o Collection schemes for bottles, paper, textile, batteries etc o Home composting schemes o "Real nappy" initiative
Public educations	Waste prevention/minimization clubs
Policy regulation/legislation	• Strategy documents o Waste Strategy 2000, 2007 • Best value performance indicators for Local Councils • Landfill tax escalator • Landfill allowance trading scheme
Incentive schemes	• Financial or material compensation o Kerbside recycling/ incentives o Home composting incentives

Source: (Adapted by author).

CHAPTER THREE
METHODS

3.1: Introduction

This chapter details the methodology adopted for this study. A multi methods approach has been adopted; in this case a quantitative methodology, which incorporates to an extent some aspects of the qualitative approach. Justification for adopting the multi method approach is outlined alongside the specific methods employed for data collection. The chapter is organized in sections covering: (i) research approach (ii) waste composition analysis (iii) questionnaire design, survey and data analysis (iv) focus group discussions (v) best practise recommendations.

3.2: Research Approach

According to Pole and Lampard (2002), research is a careful search or to search again, which is capable of withstanding close examination and is aimed at gathering information, which can be used to produce or to enhance knowledge. As Bryman (1988) pointed out, aggregation of knowledge almost always follows two paradigms (1) quantitative (positivist), (2) qualitative (interpretivist) approaches. Solid waste investigation has a very broad outlook overlapping several academic disciplines from the applied to the social sciences (Olowomeye, 1991; Ezeah, 2006). As a result of this overlapping nature, data generated from waste investigations often vary from finite statistical data to the more general descriptive information common with human subject investigation. For this reason, this research adopts aspects of both quantitative and qualitative research approaches.

The nature of a research subject, its aims and objectives and the resources available for the investigation normally determines the design and strategy to be used for carrying out the investigation (Brunner and Ernst, 1986; Ibiebele, 1986). Quantitative research strategy is underpinned by experimentation and usually attempts to compare or correlate one study group with another. Qualitative research strategy on the other hand tends to rely more on case studies, employing in many cases ethnography and grounded theory. It is therefore germane to state that selection of appropriate research strategy (ies) will depend on the nature of the research (Keith, 2005). In the course of this study, the quantitative approach involving waste physical characterization and questionnaire survey were utilized to analyse waste samples as well as understand the nature of the barriers and success factors affecting solid waste

management in the case study area. The qualitative approach namely, focus group discussion and participant observation was however utilized to generate other useful supporting data especially from human subjects so as to strengthen quantitative evidence. This approach is similar to the strategy adopted by Contreras *et al.*, (2006) in determining the drivers in current and future municipal solid waste management system in Yokohama, Japan and Boston, USA. Ankrah (2007) and Nuhu (2008) are in favour of some degree of methodological liberalism in synthesizing paradigms where appropriate in environmental research.

3.2.1: Data Collection and Analysis

It is of utmost importance in a research study such as this to identify clearly what tools and procedures are to be used in data collection and analysis. As has been pointed out earlier, the nature and size of data to be collected will determine what tools and procedures will be used for data collection as well as analysis. Figure 3.1 below summarizes the process and key stages in this investigation.

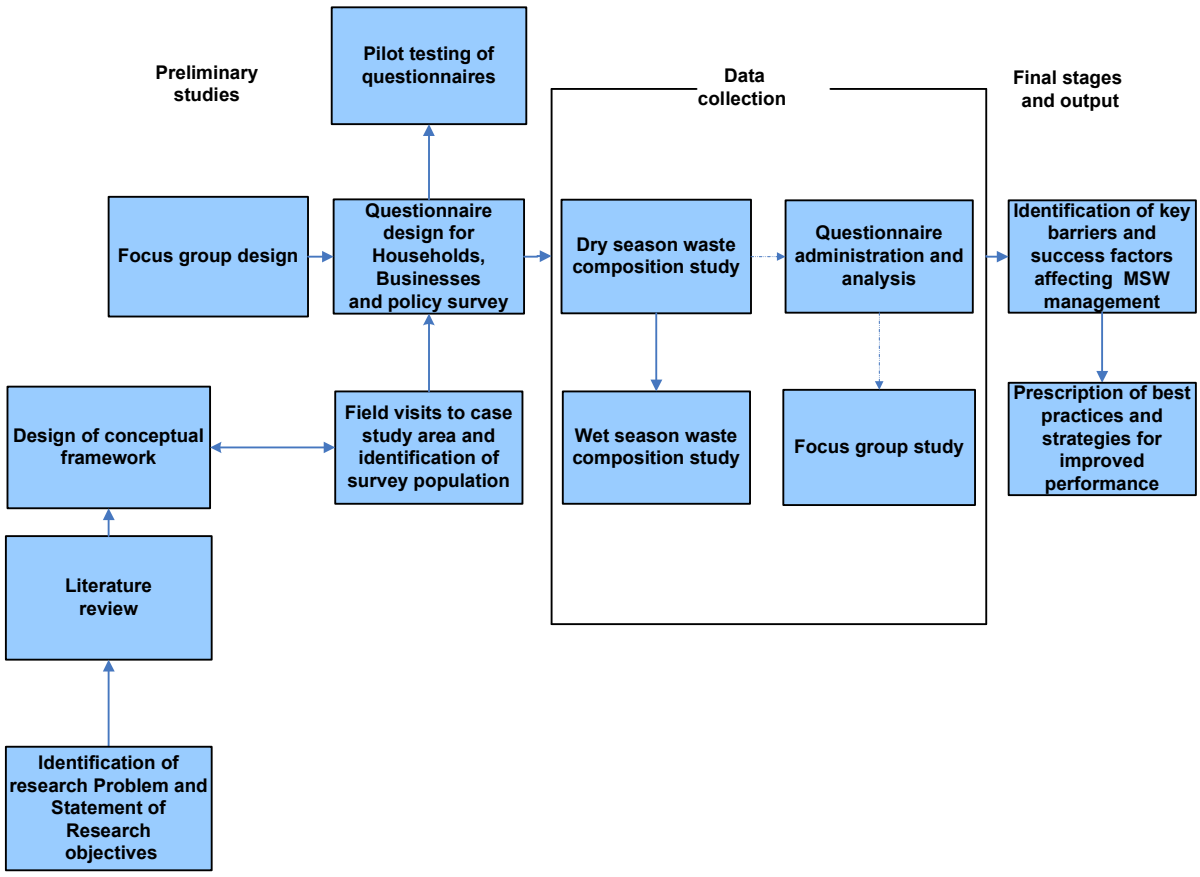

Figure 3.1: Flowchart showing the research process [after Serpell and Rodriguez (2002)].

3.3: Waste Composition Study

Primarily this waste composition study aims at developing a representative, statistically defensible estimate of the composition of municipal solid wastes samples in Abuja as expected in research aim 1, objective (d), (see Section 1.1.2). As Burnley (2007) postulated, compositional analysis was utilized to establish the basic character of the municipal solid waste stream in Abuja, Nigeria. Through the development of this composition, the study hopes to further apply the outcomes of the analysis to achieve the following objectives:

1. To establish a baseline for future characterization and measurement of MSW composition in Abuja.
2. To establish any variations in waste composition from the five districts of Abuja over different seasons of the year.
3. To apply findings from the composition study in designing sustainable MSW management strategies for Abuja and similar tropical urban environments.

Study Design:

This study adopts the following procedures:

1. Select standardized materials classification categories.
2. Conduct a pre sort-site assessment exercise.
3. Define the waste sort protocol.
4. Conduct the sampling and sorting events.
5. Review and compiling generated data.
6. Using statistical techniques to analyse the results.

Material Categories:

Samples characterization was carried out using the same material classifications format as adopted by Burnley (2007) in similar investigation, as given Table 3.1.

Pre-Sort Site Assessment:

A pre-sort site assessment was carried out at the old Mpape waste disposal facility. This was aimed at determining the suitability of the site facilities for waste characterization study. Information gathered during the pre-sort site assessment helped in the design of sampling procedures for the waste characterization study.

Table 3.1: Material classification format used for the composition analysis

Material classification	% composition (by weight in kg)
Paper	
Cardboard	
Plastic film	
Dense plastic	
Glass	
Metals	
Non-ferrous metals	
Putrescibles	
Textiles	
Misc-combustibles	
Misc. non-combustibles	
WEEE	
HHW	
Fine elements	
Total	**100**

WEEE = waste electrical electronic equipment, HHW = household hazardous waste.

Waste Sort Protocol:

After the completion of the site assessment, a waste protocol that would help achieve a consistent sample characterization was adapted from previous studies (Environmental-Protection-Agency, 1994; Chung and Poon, 2001; Burnley, 2007). Specifically, this protocol covered:

1. Waste Sourcing/Generation: Samples were collected from residential dwellings from eight sampling zones (see Figure 3.2) within Garki District of Abuja (Phillips *et al.*, 2002; Parizeau *et al.*, 2006).
2. Frequency of Sampling: To obtain a representative sample, ten samples were randomly collected from each of the sampling zones during a typical week for analysis.
3. Seasonality: Sampling was carried out once during the dry season (January-February, 2008) and again during the wet season (August-September, 2008). This was to enable the assessment of the impact of seasonality on waste stream characteristics.
4. Sampling and Sorting Events: A total of 80 samples of MSW, 10 each from the eight sampling zones was sorted, categorized, weighed and documented during the dry as well as the wet seasons. Samples were characterized using the material based categorization approach (see Table 3.1).

5. Statistical Analysis: Data from the sorting events was processed using the Statistical Programme for Social Sciences (SPSS version 16.0) and Microsoft Excel software packages. Descriptive statistics were initially generated followed by further statistical tests for variance using Analysis of Variance (ANOVA) and Chi Squared tests.
6. Results: The results from statistical analysis were compared to establish any similarities or differences.

Table 3.2: Overview of socio demographic characteristics of sampling area

Sampling zone	No of samples collected	Geographic description	Demographic classification	Average Household size	Income classification
1	10	Garki Area1	Medium density	5-7	Low Medium
2	10	Garki Area 10	Medium density	5-7	Low Medium
3	10	Garki Area 3	Medium density	5-7	Low Medium
4	10	Garki Area 8	Medium density	5-7	Low Medium High
5	10	Garki village (Garki II)	High Density	8-10	Low Medium
6	10	Kaltungo/Karaye Area (Garki II)	Low Density	2-4	Medium High
7	10	CBN Estate (Garki II)	Low Density	2-4	High
8	10	Gimbiya Street Area	Medium density	5-7	Medium High

Population density (low = <100 persons/km^2, medium = 100-400 persons /km^2, high = >500 persons/km^2)
Income levels (low = 7,500- 30,000 Naira, medium = 30,000-100,000 Naira, high = >100,000 Naira).
Note: £1 = 230.933 Naira (09/04/10).

3.3.1: Case Study Area

Garki district of Abuja was selected as the sampling area because the district broadly captures the range of socio-demographic characteristics that exist in most parts of the City which are relevant to this study (see Table 3.2 above). The District was sub-divided into eight sampling zones (see Figure 3.2) after the methods developed by Open University (2005) and Parizeau *et al*. (2006). Samples of weekly waste arising were taken from ten randomly selected households in each of the sampling zones during the peaks of the two seasons that exist in the tropics, dry and wet seasons.

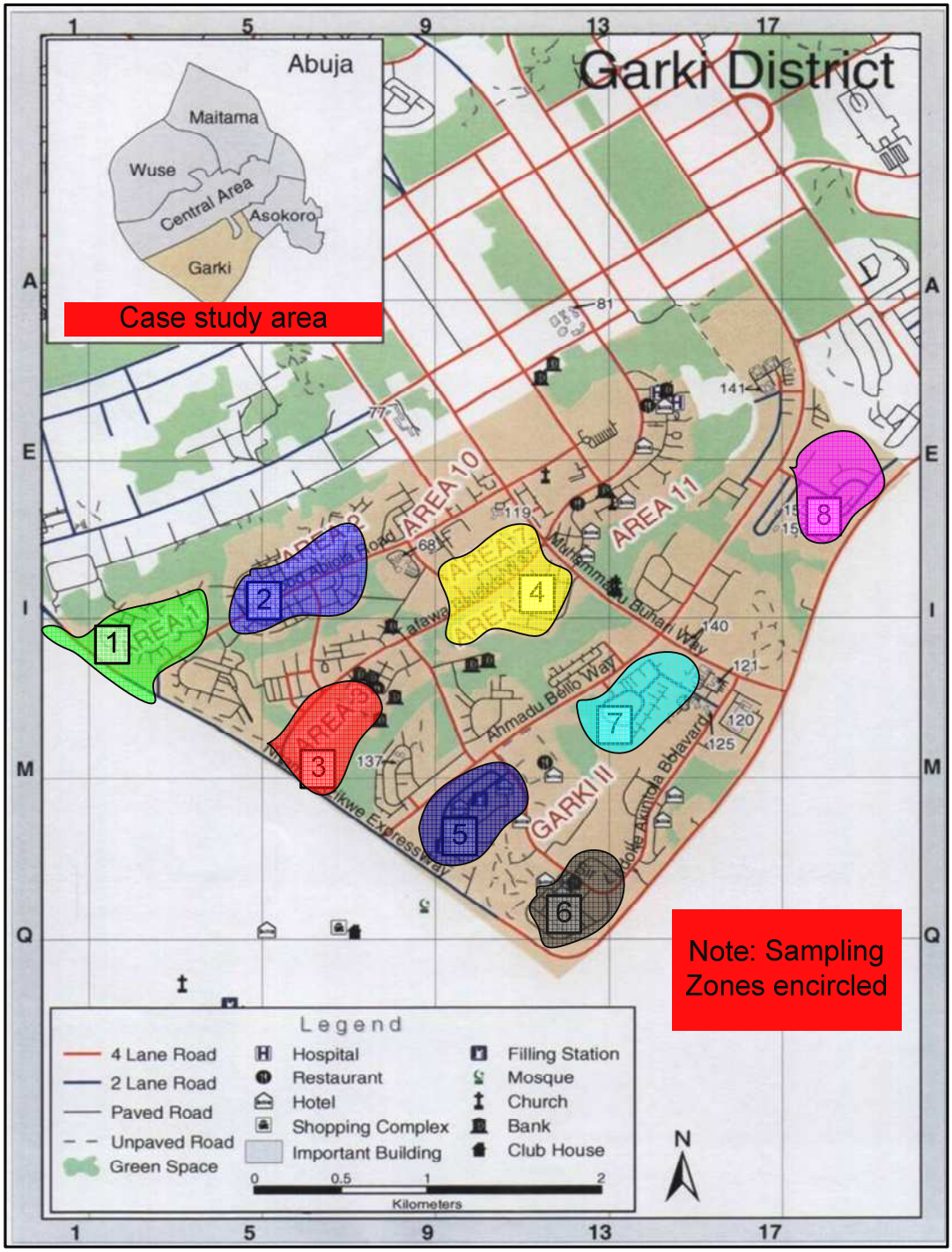

Figure 3.2: **Map of case study area outlining sampling zones [adapted from (Mohammed *et al.*, 1999)].**

3.3.2: Data Collection: Waste Compositional Study

Literature contains several methods for solid waste characterization (Dahlén and Lagerkvist, 2008). In all however, two broad approaches exist i.e. material-based categorization of components and methods based on "potential use" of segregated materials (Parizeau *et al.*,

2006). This study adopted the traditional and simpler material based classification approach developed by Burnley (2007).

Samples from individual households were collected in black bin bags and labelled with unique identification marks. Collected samples were transported in pick up vans to a covered sorting facility where they were initially weighed to determine overall weight of sample, then segregated using the predesigned fourteen character template (see Photos 3.1 below) into paper, cardboard, plastic film, dense plastic, glass, metals, non-ferrous metals, Putrescibles, textiles, miscellaneous combustibles, miscellaneous non-combustibles, WEEE, HHW and fine components, after Chung and Poon (2001) and Dahlen and Lagerkvist (2008). The remaining material was a mass of mainly biodegradable material termed putrescibles in this study.

Segregated components were again weighed to determine their weights as a percentage of the total weight of sample. About 1kg weight of each sample material was collected in polyethylene bags during the wet season sampling and taken to AEPB materials laboratory for moisture content determination. Analysis of each sample had to be completed within a day to reduce errors introduced by field conditions. Data collected during the two seasons were analysed statistically using Analysis of Variance (ANOVA) to identify key similarities or differences.


Photos 3.1: Waste sampling and characterization at the Mpape dumpsite and AEPB laboratories (author's photographs).

Possible Sources of Error

Dahlen and Lagerkvist (2008) listed possible sources of errors in a solid waste sampling procedure to include errors due to spatial and periodic variations. To reduce the probability for procedural error, all assistants used or the sampling underwent training. The same set of assistants was used throughout the sampling process. Notwithstanding, possible error sources during this investigation may include sample preparation, increment extraction, grouping,

segregation and fundamental errors. As a traditional balance was used for weighing the samples and segregated components under site conditions, the sum of weights of segregated components sometimes differed from the initial weight of entire sample before segregation. On the average a net gain or loss of 0.2% to 0.5% was observed with rare discrepancies up to 4.3% in the wet season. This compares reasonably with figures obtained by Chung and Poon (2001), 6.6% and Parizeau *et al*. (2006), 2.7%.

3.4: Design of survey questionnaires

The study employed three separate questionnaire surveys (for households, businesses and waste policy makers) in collecting data on the barriers and success factors that affect MSW management in Abuja (see research aim 2, Section 1.1.2). Appendix 1 presents a blank copy of the household questionnaire as designed by the author. Basically, all three questionnaires were similar in structure, but each was adapted to illicit required responses from target population. The rationales that informed the choice of questions included (1) The desire to obtain data that on analysis could help realise the immediate objectives of the research (2) To gather data in critical areas of MSW management in the City where presently there is none. Oppenheim (1992); De Vaus (2007) and Baker (Baker, 2003) have variously outlined the critical essentials of a good survey and recommended best practises for questionnaire design and administration. Following their recommendations, the questionnaires were designed for self or guided completion and worded so as to be brief, easy to read and understood; completely without bias or ambiguity.

3.4.1: Pilot Survey

Pilot studies are often essential to establish that a questionnaire is well designed and will be able to achieve all the data gathering objectives of the main survey. According to Munn and Drever (1990), apart from being useful in evaluating the clarity, feasibility and comprehensiveness of a survey, pilot studies go a long way in testing the rigour and robustness of methodological frameworks for surveys. To ensure validity of responses, it is often necessary to ensure that the sample for pilot survey is selected from, or approximates to, the actual sample of the main survey (Pole and Lampard, 2002). As a result of the distance from the case study area, time and cost constraints, sample for the pilot survey in this research has been drawn from Nigerian students at the University of Wolverhampton who have had a contextual knowledge of the case study area.

An online format of the survey was adapted using the Surveyor sampling software. This online questionnaire was thereafter mailed to 250 students of the University via the University's International Students' office in June-July, 2008. A total of 57 responses were returned equivalent to about 23% response rate. This rate is well within the norm according to Black *et al.*, (2000), who stated that in most cases a response rate of 20-30% is normal for postal questionnaires. Analysis of the pilot survey results provided useful insight into parts of the questionnaire that needed to be revised prior to the main survey. From the feedback provided by respondents, some questions were reframed and average time to complete one questionnaire was reduced from 30 to 20 minutes.

3.4.2: Sample Size Determination

As stated earlier, the questionnaires were administered to three categories of respondents: households, businesses and policy makers in government agencies charged with waste management. In all cases it was ensured that respondents were either Abuja residents or those who work within the five districts of Abuja Municipal Area Council (AMAC). This criterion of allowing people who work in the City to participate in the survey made it possible for respondents who ordinarily reside in the satellite towns of Abuja such as Nyanya, Karu, Kubwa and Lugbe but work, or have businesses located, within the five districts in the municipal area to also participate in the survey. In other to determine a suitable sample size, a sample size calculator provided by Research Information (2008) was utilized. By assuming a City population of 405,000 (National Population Commission, 2008), and a confidence level of 95% (0.05) after (Munn and Drever, 1990), a sample size of 1064 was calculated for household respondents. Similarly, by assuming populations of 500 and 300 for businesses and waste policy makers, respectively, sample sizes of 341 and 234, respectively, were calculated; thus giving a total sample size of 1639 for the entire survey (three sets of questionnaires) as detailed in Table 3.3 below. Household questionnaires were to be completed by the head of the household or a responsible adult in their absence.

Table 3.3: Sample size calculation

	Confidence level (%)	Confidence interval	Population size	Sample size
Household survey	95	3	405,000	1064
Business survey	95	3	500	341
Policy makers survey	95	3	300	234
Total				**1639**

3.4.3: Questionnaire Administration

Babbie (1990) and Creswell (2003) have exhaustively discussed key issues affecting postal questionnaire surveys and response rates. It is their opinion that, for most studies, a response rate of between 20-30% is normal even in the context of developed countries, with very good postal infrastructure. Given that postal services in Nigeria at the time of this study are not as reliable as in those developed countries, a decision was made to use the direct door stepping questionnaire administration approach after the method adopted by Phillips *et al*., (2002) and Read *et al*. (2009). An obvious advantage of this strategy is to enhance the rate of return since the questionnaires were normally delivered directly by hand to the respondents and taken back immediately on completion. In their study, Phillips *et al*., (2002) reported a return rate of about 98%. An important drawback of this approach is that it is laborious, time consuming and expensive. Using this method, the researcher hired two assistants to assist in the administration of the questionnaires to randomly selected households between August and September, 2008. At the end of the exercise, a total of 1557 questionnaires were returned, an equivalent to a 95% return rate. Table 3.4 is an outline of respondents' groups in the survey.

Table 3.4: Respondents' groups

type of respondent	Frequency	Percent	Valid Percent	Cumulative Percent
households	1204	77.3	77.3	77.3
businesses	200	12.8	12.8	90.2
policymakers	153	9.8	9.8	100.0
Total	1557	100.0	100.0	

3.5: Design of Focus Group

Denzin and Lincoln (1994) defined Focus Group Discussion (FGD) as a collective conversation or group interview. The size of the group may vary from small (6 persons) to large (12 persons) and may or may not be guided by a facilitator. The main purpose of a focus group discussion is to obtain in-depth information relating to concepts, perceptions and practises in the context of the subject from members of the group (Morgan, 1998). Ideally this is not a question and answer session but an opportunity to gain insight on the subject from the point of view of experts, practitioners and stakeholders in a purely interactive session.

Focus Group Discussion methodology has been used successfully by Mbeng (2009), Refsgaard and Magnussen (2009) as well as Balch and Mertens (1999) in similar studies on municipal solid waste management for the formulation of research questions, gaining greater insight on the subject and resolving unexpected issues encountered by questionnaire and interview methodologies.

For the purposes of this discussion, four parallel FGD sessions of four participants each were held (see Photo 3.2); with the researcher acting as the facilitator. Appendix 3.7.1 is a copy of an invitation for participation in the FGD while Appendix 3.7.2 lists all participants with their contacts. Participants were mainly drawn from Abuja Environmental Protection Board (AEPB), Federal Capital Development Authority (FCDA), Nigerian Society of Engineers, National Assembly and Scavenger's Association. Other participants came from the academia, waste services providers, NGOs as well as ordinary residents of the City.

Photo 3.2: Participants at parallel sessions of focus group discussion (author's photo).

3.5.1: Data Collection: Focus Group Discussion

The earlier quantitative methods: waste composition analysis and questionnaire survey provided critical ingredients for the proper understanding of present MSW management practises in the City. The purpose of the focus group discussion was therefore to strengthen and corroborate evidence and findings from these earlier methods. Participants in the group discussion were randomly drawn from a short list of stakeholders in the City. The main factors considered while selecting participants were:

- Knowledge of the subject.
- Participation in the questionnaire survey.
- Spread, both in terms of geographical and sectoral representation.

The process for recruitment of participants involved sending a formal invitation letter and subsequently a telephone confirmation of attendance when requested by the participant. Initial recruitment started in August, 2008. The total number of invitations sent to participants was 18 while a total of 16 participants eventually turned up for the discussion.

Focus Group Design:

The objectives of the Focus Group Discussion were:

a) To provide a platform for stakeholders to discuss the barriers and success factors affecting sustainable municipal solid waste management in Abuja.
b) To strengthen evidence and findings from waste composition analysis and questionnaire survey.
c) To prescribe policy options for achieving sustainable management of municipal solid waste in the City based on available evidence.

The FGD provided a relaxed and semi-formal atmosphere that encouraged participants to freely air their views on the subject. A mix of small group activity exercises and full group discussion was adopted. Following an ice-breaker exercise and general introduction, a small group exercise was conducted to determine participants' levels of understanding of the subject. During the ice breaking discussions, participants were divided into four groups of four discussants each ensuring that people who might know each other were separated. The exercises were recorded by audio as well as video means for subsequent transcription; small group activities were based on an interactive team exercises. Such exercises were completed and collected after each session; and feedback to the full group recorded on flipcharts. The Focus Group was facilitated by the author.

The information gathered from the transcript, handouts and flip charts during the small and whole group sessions were then synthesized to provide an overall position of the entire focus group on current municipal solid waste management practise in Abuja. This was with a view to prescribing strategies and policy options for adapting global best practises that will suit local conditions.

3.6: Data Analysis

Two sets of data were obtained from the waste compositional analysis and the questionnaire survey. Analysis of data from the waste composition study was carried out using Microsoft *Excel* for Windows while data generated from the questionnaire survey were analysed using the *Statistical Package for the Social Sciences (SPSS).* Some of the data from the questionnaire survey were nominal in nature. According to Field (2000) and Tabachnick and Fidell (2001), such data are best analysed using descriptive and inferential statistics. Most of the data generated from the questionnaire survey were however ordinal in nature (responses were mainly ratings measured on the Likert scale). This group of data were initially subjected to a test for normality which showed that data was approximately normally distributed. Following Tonglet *et al.* (2004a), analysis of such rating data done using parametric statistical tests, namely Analysis of Variance (ANOVA) and Chi-square tests.

3.6.1: Descriptive Statistical Analysis

Descriptive statistics describe samples of subjects in terms of variables or combination of variables (Tabachnick and Fidell, 2001). Descriptive statistical analysis therefore involves the use of frequencies, percentages, means and standard deviation to describe various variables encountered during the study. These techniques were employed for analysing data relating to the characteristics of the respondents or organizations they represent. Sometimes it was also necessary to employ these techniques for the initial analysis of certain variables even when responses were measured on a Likert scale. Graphical techniques utilized for presenting the results from these analyses include pie chart, bar chart and tables.

3.6.2 Analysis of Variance (ANOVA)

Where there was a need to compare groups of cases for differences in their means, Analysis of Variance (ANOVA) is often the best statistical test option. ANOVA is a technique for testing simultaneously whether two or more population means are significantly different

(Tabachnick and Fidell, 2001). Essentially, ANOVA is a set of analytic procedures based on a comparison of two estimates of variance. In this procedure, one estimate comes from the differences among scores within each group. This estimate is considered a random or error variance. The second estimate of variance comes from differences in group means. This is considered a reflection of group differences. Where two of these estimates do not vary significantly, a conclusion is made that all of the group means come from the same sampling distribution of means and that the slight differences between them are due to random error (Tabachnick and Fidell, 2001). Where, however, the group means differ significantly, a conclusion is made that they were drawn from different sampling distribution of means, and the null hypothesis that the means are the same is rejected.

Analysis of variance can be summarized mathematically in terms of the partition of the sums of squares as Equation 3.1:

$$SS = \sum(x - \bar{x})^2 \quad \text{Equation 3.1}$$

Where SS = sums of squares, x = individual estimate and $\bar{x}$ = average or mean score

The variance of *n* measurements is therefore given by Equation 3.2

$$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$$

Equation 3.2

Where χ and $\bar{\chi}$ are individual scores and group's mean score, respectively.

The numerator part is called the *sum of squares* of deviations from the mean, and the denominator is called the *degrees of freedom.*

The square root of variance is standard deviation, S, a measure of variability (Equation 3.3).

$$S = \sqrt{S^2} - \quad \text{Equation 3.3}$$

ANOVA test could be within subject, between subject, mixed within and between subjects or factorial between subjects. One way ANOVA is the method of choice when testing for differences between multiple groups. It assumes that the mean is a valid estimate of centre and that the distribution of the test variable is reasonably normal and similar in all groups (Field, 2000). Evaluation of more than one way ANOVA is very complicated hence requiring computer aid.

3.6.3: Chi–Square Test

The chi-square (χ^2) test is a non-parametric procedure that tabulates a variable into categories and computes a chi-square statistic to test the hypothesis that the observed frequencies do not differ from their expected values (Ankrah, 2007). In χ^2 tests, the null hypothesis generates expected frequencies against which observed frequencies are tested. Where the observed frequencies are similar to the expected frequencies, it means the value of χ^2 is small and the null hypothesis is retained; if however they are significantly different, it means the value of χ^2 is large and the null hypothesis is rejected. Mathematically, this relationship can be represented as Equation 3.4

$$\chi^2 = \sum (f_o - f_e)^2 / f_e$$ ----------Equation 3.4

Where f_o represents observed frequencies, and f_e represents the expected frequencies (Tabachnick and Fidell, 2001).

3.7: Validation of research findings

At this point, it is necessary to assess the reliability and validity of this research. Validity is one of the main concerns with research. A piece of research work can be affected by different kinds of factors. These factors could be either internal or external to the investigation and capable of invalidating its findings (Seliger and Shohamy, 1989). Controlling all possible factors that threaten the research's validity is a primary responsibility of every researcher.

Internal validity is affected by flaws within the study itself such as not controlling some of the major variables, or problems with instruments used in the research. Research results can be said to be internally invalid because they may have been affected by factors other than

those thought to have caused them, or because the interpretation of the data by the researcher is not clearly supportable (Seliger and Shohamy, 1989). Factors which affect internal validity include: sample population, time, attrition and instrument sensitivity.

The extent to which one can externalize/generalize the findings from a piece of research to a larger group or other contexts is termed external validation. In other words, a research that lacks external validity cannot be applied to other contexts. Factors that affect external validity include: population characteristics, research environment, researcher influence, time and data collection methodology.

3.7.1: Internal Validation

Internal validation is primarily an assessment of the extent to which factor "X" could have influenced the arrival at research result "Y". According to Rosenthal and Rosnow (1991), internal validation emphasizes the importance of good research design for achieving internal validity. There are no specific procedure recommended by literature for checking whether indeed good internal validity has been achieved (Ankrah, 2007). In seeking to evaluate the internal validity of this research therefore, the strategy implemented in Mbeng (2009) and Woolridge *et al.*, (2005) was followed.

This strategy involves the search for convergence between:

- Research findings
- Published research

The principle in this strategy is that if convergence is demonstrated between research findings and published research, then deductions about "X" and "Y" made on the basis of findings from this research are valid. By implication there is an indication of internal validity of research design. This strategy also provides an opportunity to compare findings from this research against other published studies examining the same issues. It is needful to point out that the absence of convergence does not necessarily imply a lack of internal validity. Rather, it may well be a sign of new insight (Ankrah, 2007).

3.7.1.1: Convergence of Research Findings and Published Research

It has earlier been pointed out that published studies on MSW management in Abuja which could provide an ideal basis for comparison of this nature are very few. Discussions and results from the preceding chapters of this thesis have however demonstrated that findings from this research are mostly supported by published literature from similar studies on other

Nigerian cities (Olowomeye, 1991; Adama, 2007). Comparisons from results of MSW composition analysis particularly demonstrate a strong convergence with results from similar studies in Uyo, Port Harcourt and Makurdi (John *et al.*, 2006; Igoni *et al.*, 2007; Sha'Ato *et al.*, 2007). Taken together, these results provide a basis for the internal validation of results from this investigation (Brinberg and McGrath, 1985).

3.7.2: External Validation

External validation confers greater confidence in the quality of a research finding (Nuhu, 2008). In other words, it is primarily targeted at ensuring the robustness of the research and about its applicability in the widest possible dimension (Rosenthal and Rosnow, 1991). Broadly, external validation consists of three components: replication, convergence analysis and boundary search. Brinberg and McGrath (1985) are of the opinion that it is this process of validation that transforms research information into knowledge.

3.7.2.1: Replication

As Brinberg and McGrath (1985) pointed out, research replication is concerned with determining whether the set of findings from a research investigation can be arrived at or reproduced when the same instruments, research design, and research strategy are used i.e. assessing the extent to which the same findings occur if the study is repeated with no factors varied?

Research replication is in other words described as the test of reliability of the research. In reality, it is not possible to have an exact replication given that no two occasions are ever the same (Ankrah, 2007). For an investigation such as this one, beyond the logistical constraints of repeating this survey, it is also unrealistic to expect that the same respondents would be willing to complete the same survey again. For these reasons it may not be possible for this survey to be directly replicated. It must however be emphasized that the questionnaire was developed and pilot tested, to ensure that the data collected was accurate and reliable.

3.7.2.2 Convergence Analysis

The principle of convergence otherwise referred to as triangulation is key to assessing the robustness of a piece of research (Rosenthal and Rosnow, 1991). Convergence analysis assess the broad range of conditions (scope of the findings) under which the findings will hold. Convergence is achieved when there is agreement of substantive outcomes derived from the

use of different and independent models, methods, and/or occasions (Ankrah, 2007). In other words, unlike replication, some of the factors are consciously varied, the study is repeated and the results are assessed to see if they converge with the original findings. In the case of this research, results from the FGD has been used primarily a method to validate the findings from the questionnaire survey and compositional analysis.

3.8: Best Practise Recommendations

Information synthesised from literature review, MSW compositional analysis, questionnaire survey and focus group discussion form the basis of deductions that have been made and conclusions arrived at in respect of this research. A number of best practise recommendations have been proposed to realign current management practises in the City with global best practise (see chapter 8).

3.9: Summary

This chapter has reviewed the research methodology used in carrying out this study. A mixed methods approach employing qualitative and quantitative research methods was utilized. Firstly, a detailed literature review was carried out followed by a two stage waste composition analysis. Following this, three sets of questionnaires were designed to sample the opinion of households, businesses and waste policy makers in Abuja as to the main barriers and success factors affecting sustainable management of municipal solid waste in the City. Prior to a full scale questionnaire survey in the case study area, a pilot survey was carried to validate and fine tune aspects of the questionnaire (this method is designed to realise research aim 2 and associated objectives). A focus group discussion was carried out drawing participants from the respondents to the main questionnaire survey to complement the other methods and to explore in greater details issues that arose in the course of applying the earlier methods.

Data collected are analysed using the Statistical Programme for Social Sciences, (SPSS) and Microsoft Excel software packages. Key statistical test carried out included the Analysis of Variance (ANOVA) and Chi-Square tests. The output of the data analysis forms the basis of the deductions and conclusions that are proffered in this research to address its overarching aims and objectives (see research objective 3c, Section 1.1.2). A number of best practise recommendations have been presented alongside a set of strategies designed to achieve sustainable MSW management in the City of Abuja.

CHAPTER FOUR
WASTE COMPOSITION ANALYSIS

4.0: Introduction

This chapter presents the results of the two-stage waste compositional analysis that was conducted between January and September 2008 to characterize MSW samples from the case study area, and to establish any variations between samples taken during the dry and wet seasons.

The chapter is organized in sections covering: (i) Socio-demographic data of sampling zones (ii) Climatic data, temperature, rainfall and relative humidity data (iii) Moisture content analysis results (iv) Results of waste composition analysis by sampling zone (descriptive statistics) (v) Results of statistical test of variance (vi) Conclusions and recommendations

4.1: Socio Demographic Data of Sampling Area

Table 3.2 represents an overview of the socio-demographic characteristics of the sampling area. The sampling area is largely a residential area interspersed with small business and a number of government offices, schools and churches. Population density ranges from low in Zone 7 to high in Zone 5. Income levels of residents also varied widely both within and across sampling zones.

4.2: Climatic Characteristics of Sampling Period

The Nigerian climate is characterized essentially by the interplay between the dry north-easterly and the moist south-westerly winds. The prevailing effects of these air masses largely drive seasonal changes in the country. The influence of climatic peculiarities on waste characteristics is well documented in the literature (Dayal *et al.*, 1993).

Seasonal and climatic dynamics in the tropics are defined essentially by high annual precipitation (up to 2,000 mm) with frequent precipitation in the wet season, high temperature (25-35°C) and relatively high humidity (60-80%), as well as a distinct dry season of up to 150 days per year (Miyajima, 1997). Maximum temperatures for Abuja obtained from the Nigerian Meteorological Agency station in Maitama Abuja during this study was in the range of 31-35°C while minimum temperature was in the range of 15-20°C (NIMET, 2008a). January is generally a dry month with low moisture in the atmosphere over the

central and northern states of Nigeria. The wet season spans from April to October. The months of July-August usually records the highest amount of precipitation during the year (up to 300 mm per month) (NIMET, 2008b). Generally climatic conditions throughout the study period were stable and typical for the region.

4.2.1: Temperature Analysis

As stated above, maximum temperature records during the sampling periods were in the range of 31°C-35°C. This indicates that observed January-February maximum was 1.2°C-4.2°C lower than the ten year average (see Appendix 3a). The distribution of minimum temperatures during dry season sampling ranged between 15°C-20°C. Minimum temperature departures during this period from ten year normals were 0.8°C-2.2°C lower (see Appendix 3b). Mean temperature analysis showed a normal distribution. Maximum temperatures during the wet season sampling period were in the range of 29°C-35°C. Observed maximum temperature during this period was 0.5°C-3.5 °C higher than long term averages. On the other hand, minimum temperatures during the wet season sampling were in the range of 21°C-27°C. It was observed that the range of minimum temperatures during this period were about 0.5°C-1.5 °C warmer than ten year averages (see Appendix 3b).

4.2.2: Rainfall Analysis

The period of the dry season sampling January-February 2008 was generally characterized by low moisture in the atmosphere (NIMET, 2008a). There were no rainfalls during this period. The period for the wet season sampling, August-September 2008 coincided with period for annual maximum rainfall. Analysis of rainfall anomaly by the Nigerian Meteorological Agency showed that Abuja recorded normal rainfall for these months (see Appendix 3c).

4.2.3: Relative Humidity Analysis

Humidity is the amount of water vapour in the air. Humidity is sometimes applied to refer to relative humidity. The term relative humidity is defined as the amount of water vapour in the air (at a given temperature) compared to the maximum amount of water vapour air could hold at that temperature, and is usually given as a percentage value (Christopherson, 2005). Relative humidity is dependent on air temperature because warm air can hold more moisture than cold air. At a relative humidity of 100%, the air is holding all the water it can at the specified temperature; any additional moisture at that point will result in condensation. At a

relative humidity of 50%, the air is holding half the amount of moisture that it could. When temperature decreases, the amount of moisture in the air does not change rather, the relative humidity increases. Relative humidity affects the rate of evaporation and the moisture content of waste samples (Dehri and Erbil, 2000; Akinbode *et al.*, 2008).

Relative humidity at Abuja averages 48.92% over the year. 21% is the lowest average monthly relative humidity which occurs in February and 73% is the highest average monthly relative humidity which occurs in August. Appendix 3d and 3e represent data for mean monthly relative humidity at (0900Z) and (1500Z) in Abuja between 1997 and 2005 (NIMET, 2008a).

4.3: Moisture Content Analysis

MSW samples were randomly selected from four households: 4.07 (household 7 in zone 4), 4.08 (household 8 in zone 4), 2.03 (household 3 in zone 2) and 2.08 (household 8 in zone 2) to determine the approximate moisture content of waste samples from the case study area during the wet season as detailed in the methods chapter (see Section 3.3.2). 10 grammes of wet samples (Ww) were weighed and oven dried at 105^{o}C for 24 hours. Final weights (Wf) of samples were noted at the end of drying. Dry weights (Wd) were obtained as the difference between final weight and weight of container (Wc). Moisture content was calculated as the difference between wet weight and dry weights (Hernández-Berriel *et al.*, 2008).

$$\text{Moisture content (\%)} = Mn = Ww - \frac{Wd}{Ww} * 100 \quad \text{Equation 4.3}$$

From Table 4.1 it can be seen that the average moisture content of wet season samples is approximately 58.5%. This result is similar to that obtained by (Igoni *et al.*, 2007) who used a similar method for a study in Port Harcourt, Nigeria. Proximate analysis of organic waste streams in that study showed moisture content of 65.2%. The implication of this level of moisture is that samples are not easily amenable to disposal options such as incineration. However, they may be more suitable for composting and various Mechanical and Biological Treatment (MBT) options such as biogas generation (Dollar, 2005; Lornage *et al.*, 2007).

Table 4.1: Moisture content determination from MSW samples

Sample Number	4.07	4.08	2.03	2.08
Weight of container (Wc)	113.2698	177.9648	141.9087	176.7482
Ww (wet weight, g)	10	10	10	10
Working temperature (t)	105°C	105°C	105°C	105°C
Drying time	24 hrs	24 hrs	24 hrs	24 hrs
Wf = Wc + weight of dry sample	117.0528	181.3922	147.4030	180.6445
Wd = Wf - Wc	3.7830	3.4274	5.4943	3.8963
Mn	62.17	65.726	45.057	61.037
Average Mn	58.50%			

4.4: Waste Composition Analysis by Sampling Zone

Results of dry and wet seasons MSW sampling from the eight sampling zones (see Chapter three, Section 3.3.1) have been presented as Figures 4.1-4.21 in this section.

4.4.1: Results of MSW Composition Analysis in Zone 1

Samples for this zone were collected mainly from Garki Area 1, a medium density neighbourhood. The socio-economic classification of households in this zone is low to medium income, as described in Table 3.2. Figure 4.1 shows MSW composition analysis of dry samples collected from the zone. Figure 4.2 shows MSW composition analysis of wet season samples collected from the same zone. From these graphs, the main components of waste stream in the dry season were putrescibles (65%), plastic film (8%), cardboard (6%), dense plastics (4%), miscealleneous combustible materials (4) and paper (3%). There is a noticeable difference in the character of the waste stream however in the wet season (Trankler *et al.*, 2005). For instance while the putrescible component reduced to approximately 50%, the quantity of plastic film nearly doubled to about 15%. Other changes include, paper (5.5%), cardboard (4.9%), miscellaneous combustibles (4.6%) and dense plastics which reduced to (2.3%). Further statistical analysis is required to establish how significant or otherwise the variations in sample composition between the seasons are. Results of statistical test carried out for this purpose are presented in Section 4.5.

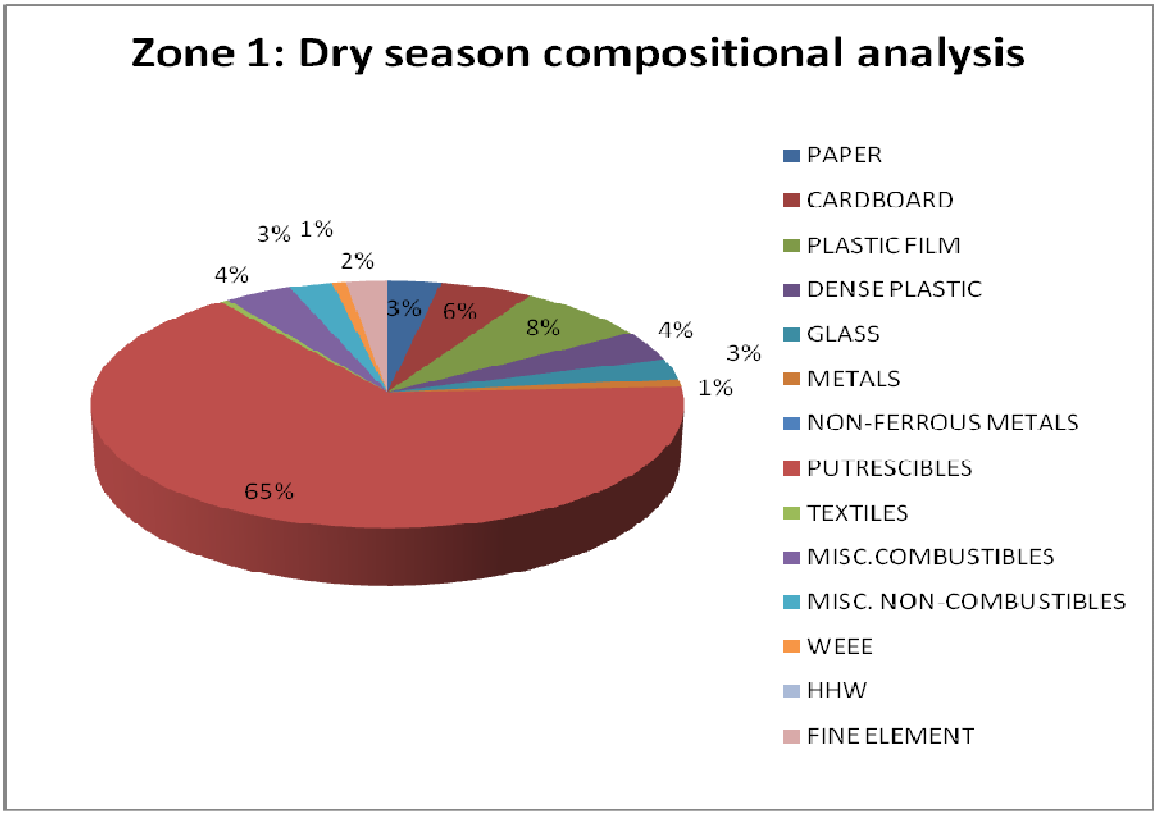

Figure 4.1: Composition of dry seasons samples from zone 1.

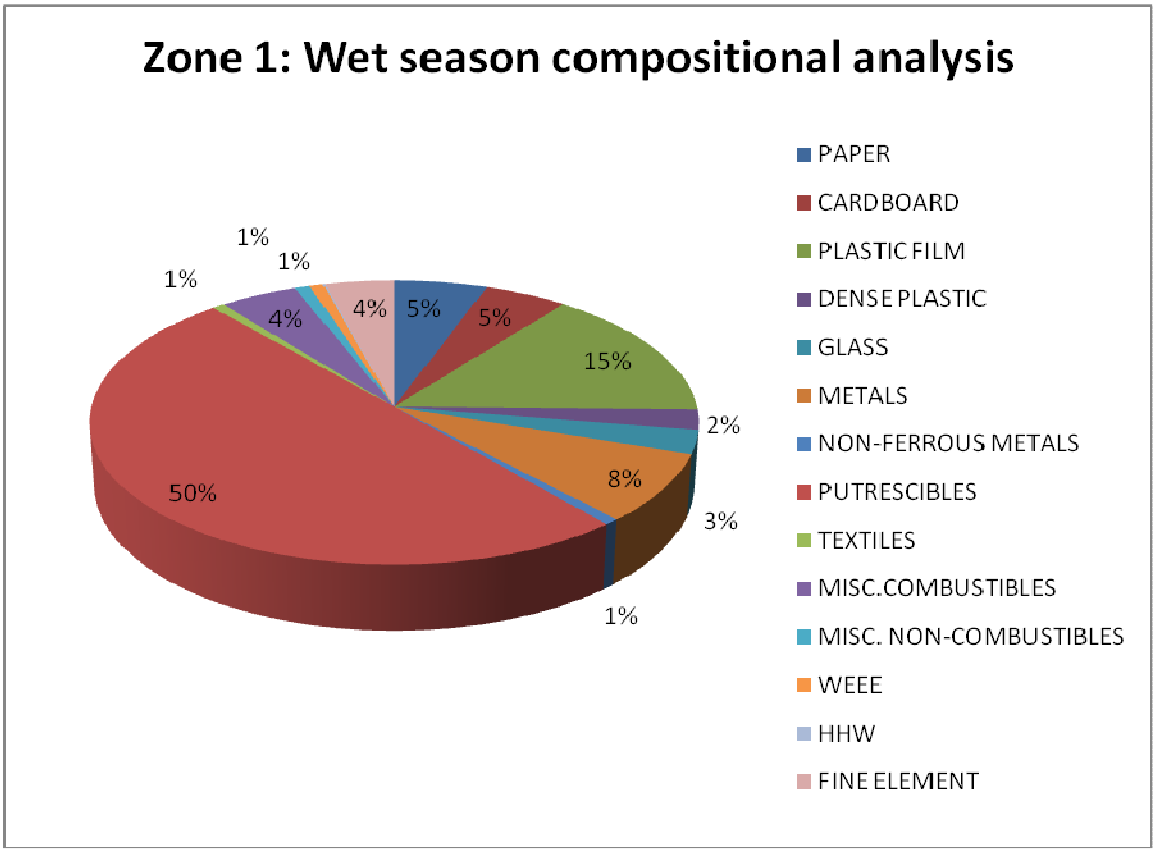

Figure 4.2: Composition of wet seasons samples from zone 1.

4.4.2: Results of MSW Composition Analysis in Zone 2

Samples from this zone were collected mainly from Garki Area 10. As in zone 1, socio-economic classification of households in this zone ranges from low to medium income as shown in Table 3.2 (Chapter three). Figures 4.3 and 4.4 graphs of MSW composition analysis of dry and wet seasons samples collected from the zone. From the these graphs, the main components of the waste stream in the dry season were putrescibles (44%), dense plastic (12%), cardboard (10%), plastics film (9%), fine elements (6%) miscealleneous combustible materials (6%) and paper (5%). During the wet season however, the quantity of putrescible component increased to approximately 52%, while dense plastic decreased to just over 3%. Other changes in the waste stream during this time include, plastic film (14%), paper (7%), cardboard (9%) and Miscellaneous combustibles (4.6%). A one way Analysis of Variance (ANOVA) test was carried out to ascertain the statistical significance of percieved variations in the composition of the samples between the seasons (Please see Section 4.5.1 below).

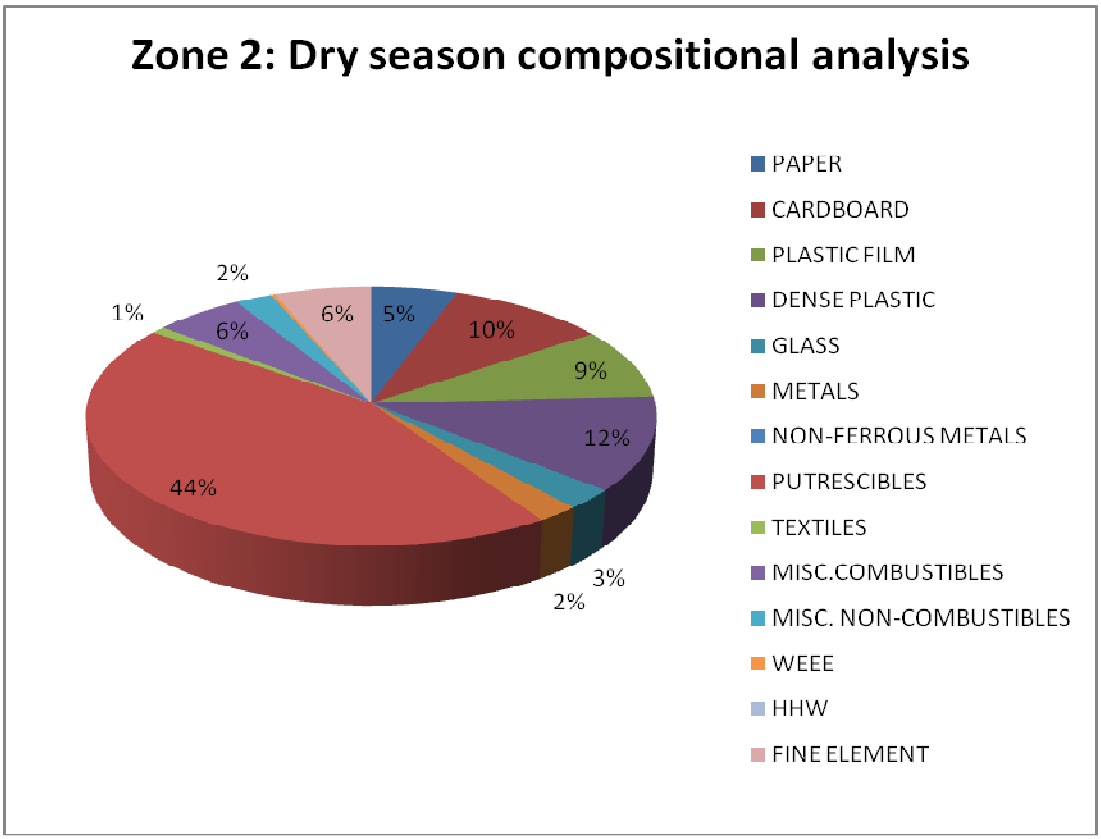

Figure 4.3: Composition of dry season samples from zone 2.

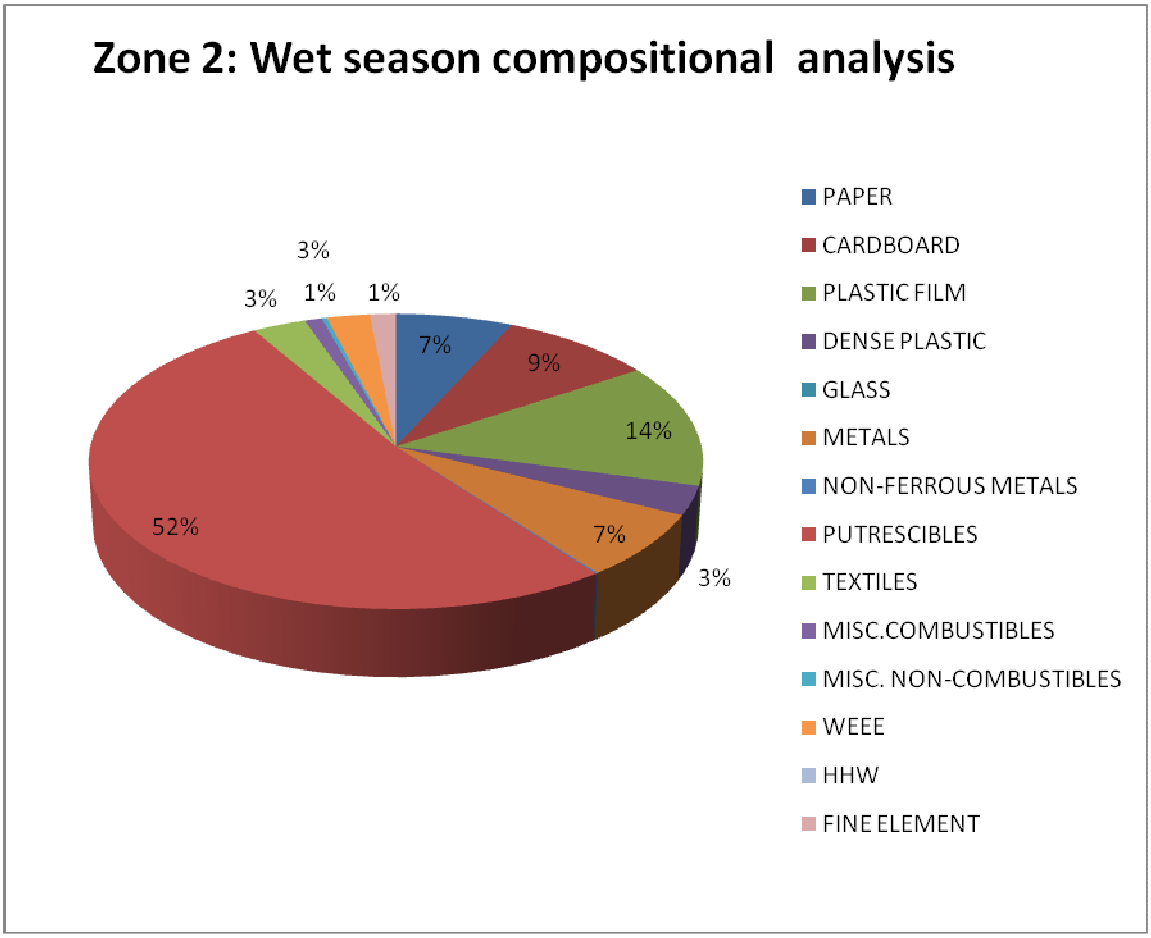

Figure 4.4: Composition of wet season samples from zone 2.

4.4.3: Results of MSW Composition Analysis in Zone 3

Samples from this zone were collected from Garki Area 3. This medium density neighbourhood has an even spread of low to medium income households interspersed with some commercial organizations and offices. Figure 4.5 shows MSW composition analysis of dry season sample collected from the zone. Equally, Figure 4.6 is a wet season compositional analysis of sample from the same zone. From these graphs, the main components of the waste stream in the dry season were putrescibles (42%), plastic film/nylon (17%), cardboard (10%), non ferrous metals (9%), fine elements (6%) paper (6%) and fine elements(6%). As in zone 2 there is a marked increase in the quantity of putrescible components in the waste stream during the wet season (52%) as compared with the dry season figures. It is thought that this increase in the organic fraction is attributable to shifts in consumption pattern from processed items to agricultural produce which are more readily available in the wet season (Dayal *et al.*, 1993). During the same period, however, the proportion of plastic film in the waste stream

decreased to just under 10%. It has been noted that drinking water is commercially sold as satchet water during the hot dry season, especially amongst the low income urban dwellers (Parrot *et al.*, 2009). As the weather gets cooler, there is a possibility that less water is consumed leading to reduced availability of discarded plastic films in the waste bins. Other noticeable changes in the waste stream during this time include, cardboard which decreased from 10% to 6% and paper, from 6% to 5%. Equally, miscellaneous combustibles saw an upward growth to 4% over the dry season level while availability of non ferrous metals sharply declined from 9% recorded during the dry season to 0.1%. A one way ANOVA test was carried out to ascertain the statistical significance of percieved variations in sample composition between the seasons (Please see Section 4.5.1 below).

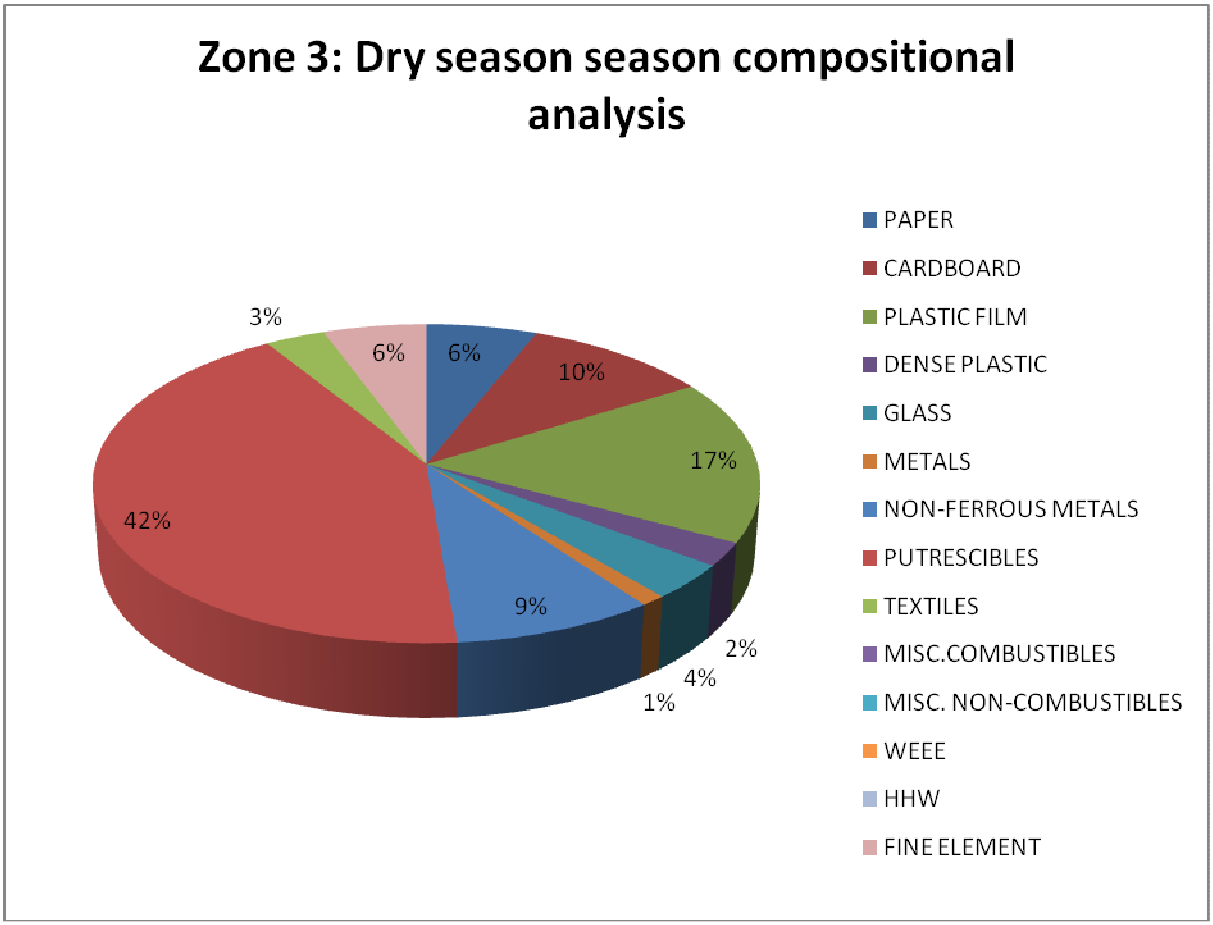

Figure 4.5: Composition of dry seasons samples from zone 3.

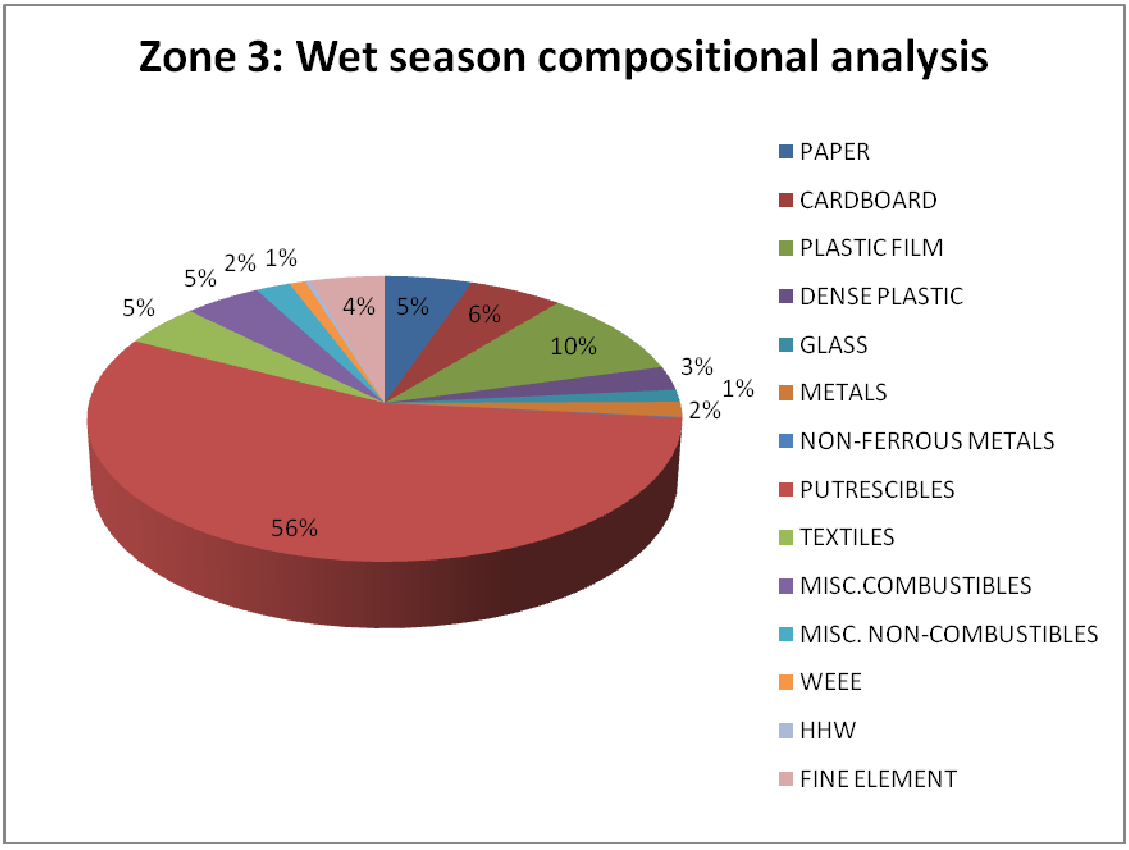

Figure 4.6: Composition of wet seasons samples from zone 3.

4.4.4: Results of MSW Composition Analysis in Zone 4

Samples from this zone were collected mainly from Garki Area 8. This medium density neighbourhood has a preponderance of high income households interspersed by some medium and low income sections. Figures 4.7 and 4.8 are graphs of MSW composition analysis of dry and wet seasons samples collected from the zone. From these graphs, the main components of the waste stream in the dry season were putrescibles (40%), plastic film (19%), cardboard (11%), paper (7%), dense plastic (5%), glass (5%). The rather low levels of organic component vis a vis the inorganic fraction such as plastics and glass is possibly traceable to the high income classifications of most households in this neighbourhood. As such they could afford more of such processed products. During the wet seasons however, there is approximately 10% increase in the quantity of putrescible component as compared with dry season sample i.e. 40% to 50%. As in previous zones this increase is possibly explained by the greater availability of biodegradable materials especially food products during the harvest season which coincides approximately to the time this sampling was carried out.The phenomeneon of post harvest losses especially in high and moderate humidity

zones have been documented in literature (Torre and Fjeld, 2001). During the same period however, the quantity of plastic film/nylon in the waste stream decreased appreciably from 19% to just under 11%. As has been noted earlier, this decrease in the quantity of plastic films or nylon is probably traceable to the reduction in demand for packaged drinking water (*pure water*) which is commercially sold as satchet water during the hot dry season in Nigeria. Other variations in the waste stream during this time include, cardboard (8%), paper (7%), miscellaneous combustibles (5%), dense plastics (4%) and fine elements (4%). Though appreciable variations in sample composition exist between the seasons, conclusive inferences on the statistical significance of this variation requires statistical test of variance (please see Section 4.5.1 below).

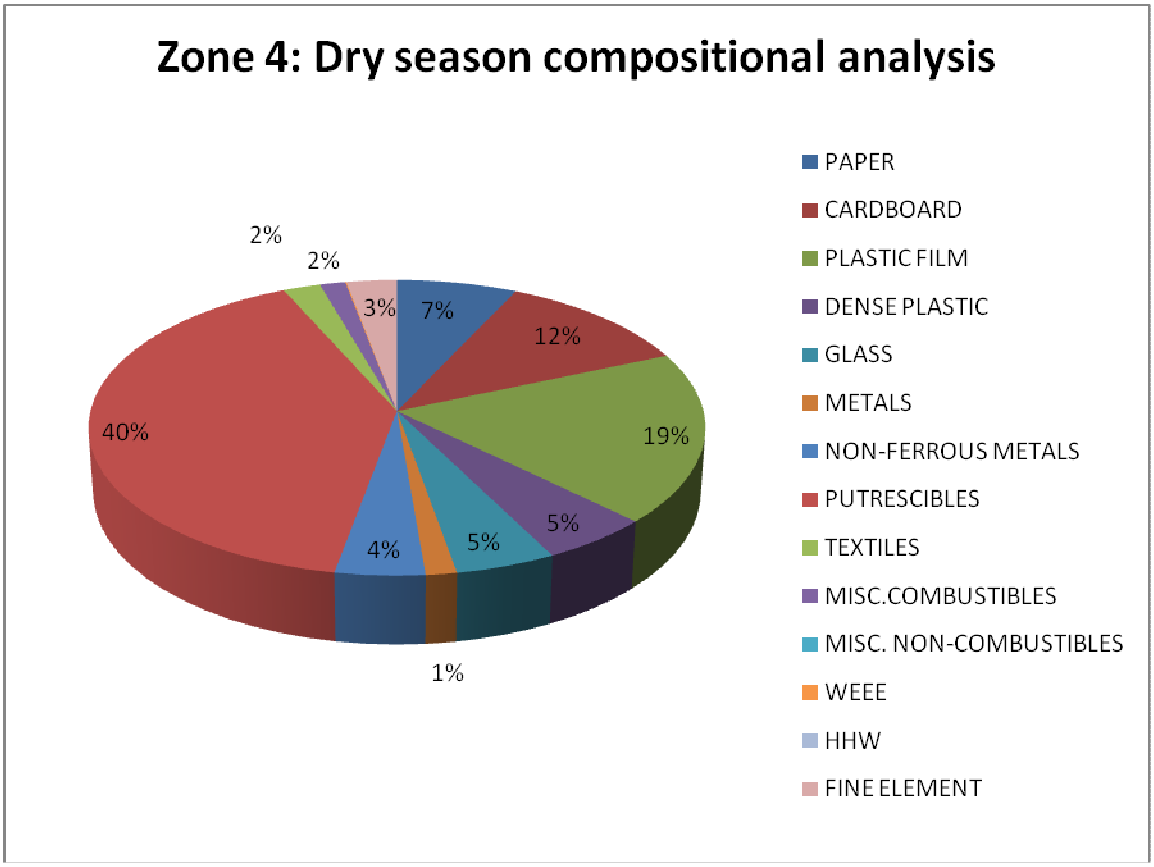

Figure 4.7: Composition of dry season sample from zone 4.

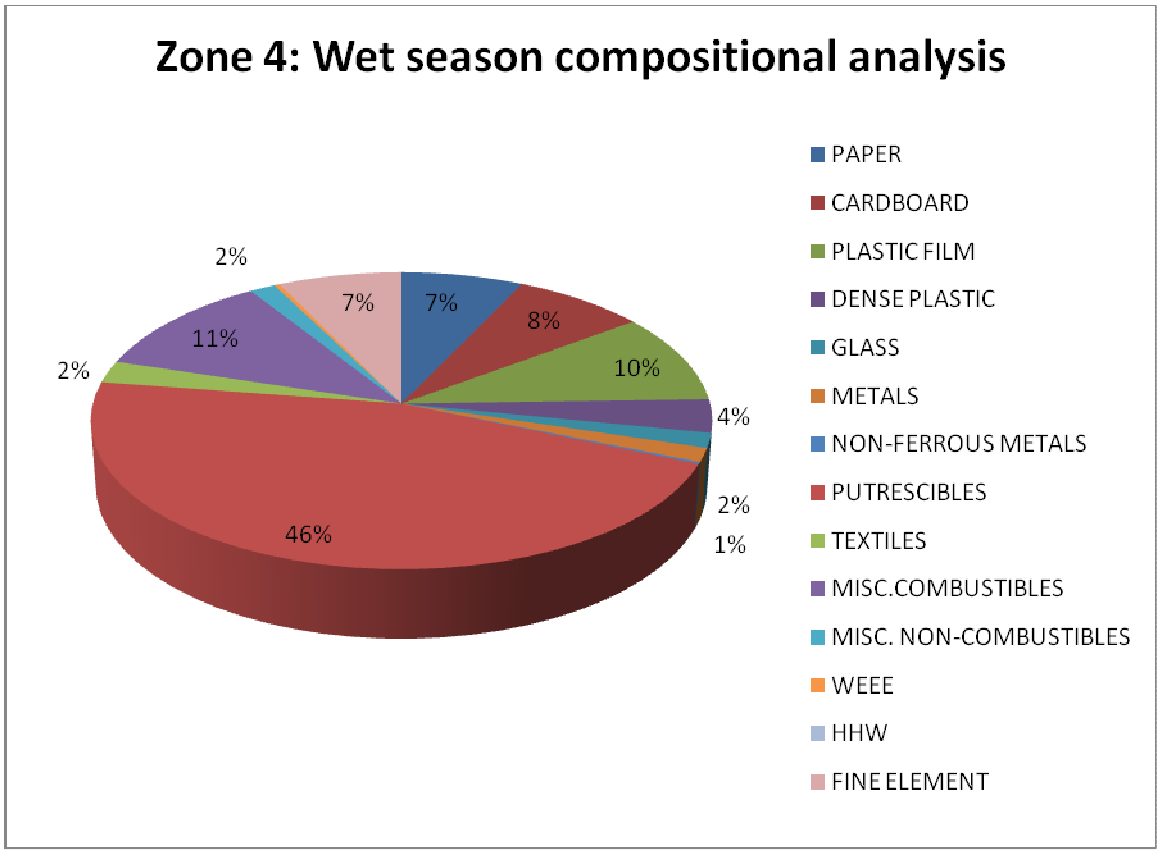

Figure 4.8: **Composition of wet season sample from zone 4.**

4.4.5: Results of MSW Composition Analysis in Zone 5

Samples from this zone were collected from Garki village. This high density neighbourhood has a predominance of low income households interspersed by some meduim income households. Figure 4.9 shows MSW composition analysis of dry season sample collected from zone 5. From the these graphs, the main components of the waste stream in the dry season were putrescibles (43%) followed by plastic film/nylon (16%), dense plastic (14%), paper (10%), glass (7%) and cardboard (5%). Quite unexpectedly, the quantity of putrescibles and other organic fractions from this zone is rather low compared with other predominantly low income neighbourhoods. Equally, there appears to be a more even distribution of key components of the waste stream in this zone compared with other zones with similar socio - economic characteristics. From Figure 4.10, there appears to be no significant change in the quantity of the putrescible components during the wet season as it grew only to 44% compared with the 43% recorded during the dry season. During the same period, however, the quantity of plastic film in the waste stream decreased from 16% to 13%.

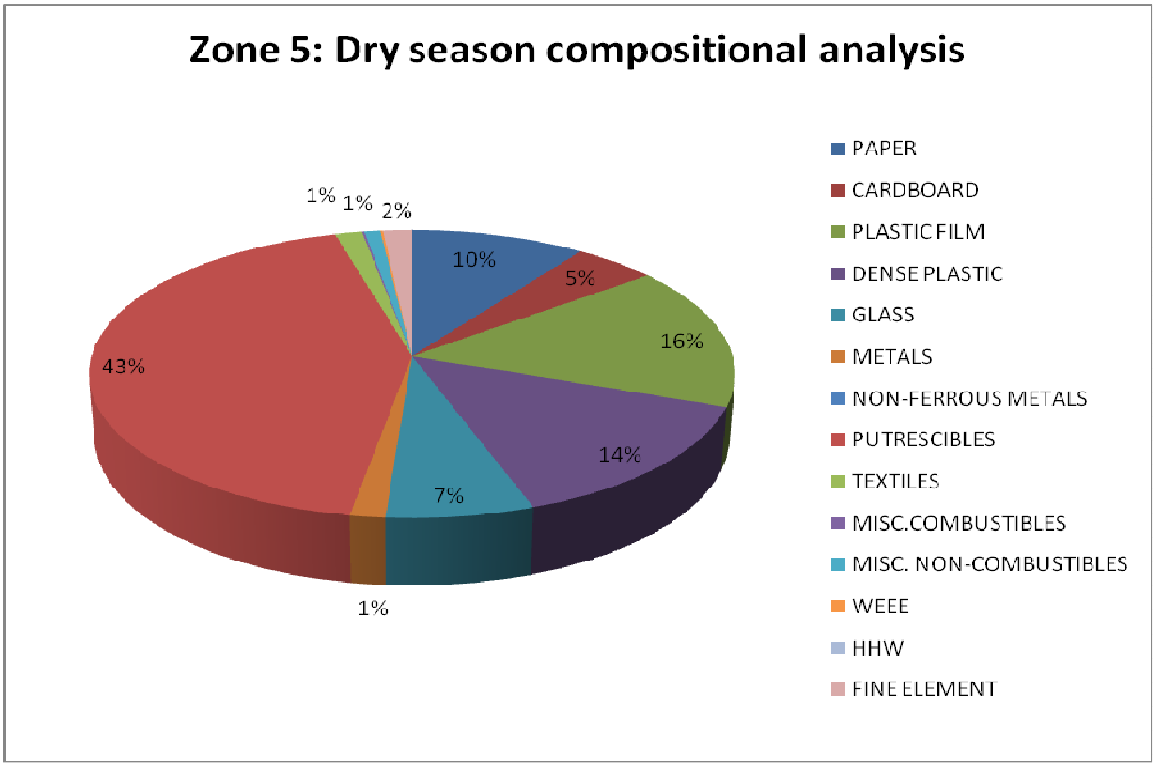

Figure 4.9: Composition of dry season sample from zone 5.

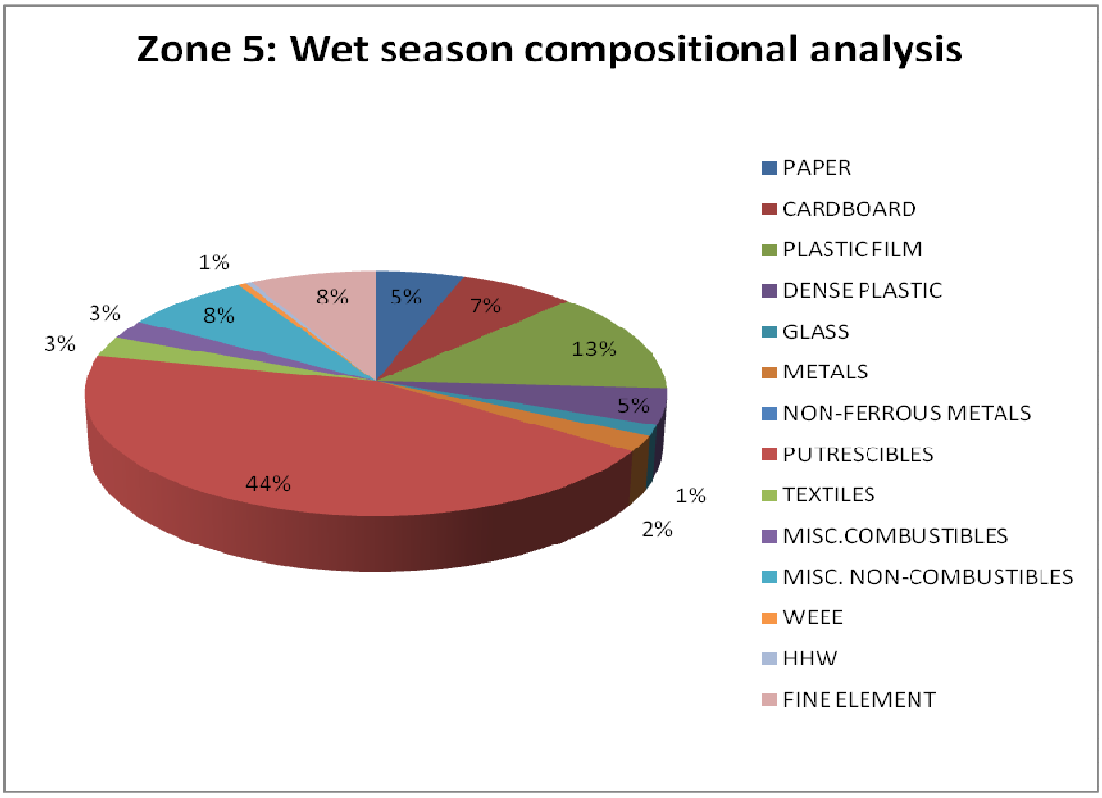

Figure 4.10: **Composition of wet season sample from zone 5.**

Other changes in the sample composition during this time include, miscellaneous non-combustibles (8%), fine elements (8%), cardboard (7%) and dense plastics (4%).

4.4.6: Results of MSW Composition Analysis in Zone 6

Samples from this zone were collected mainly from Kaltungo/Karaye area, Garki II. This low density neighbourhood has a predominance of high income households interspersed by some medium income sections. Figures 4.11 and 4.12 are MSW composition analysis of dry and wet seasons samples collected from zone 6. From these figures, the main components of the waste stream in the dry season were putrescibles (48%) followed by paper (13%), plastic film (8%), dense plastic (7%), metals (7%). Unexpectedly, the quantity of putrescibles in the waste stream dropped slightly from 48% to 46% during the wet season while plastic films increased marginally from 8% to 10%. Other major components in the waste stream during this period include cardboard (10%), paper (10%), dense plastic (5%) and metals & cans (4%). There appears to be an even spread of the major components in the waste stream during the wet season. The upward increase in the quantity of plastic films in the waste stream at this time runs contrary to the trend in the other zones already discussed. In other to ascertain the statistical significance of percieved variations in samples composition, one way ANOVA test was carried out as discussed in Section 4.5.1 below.

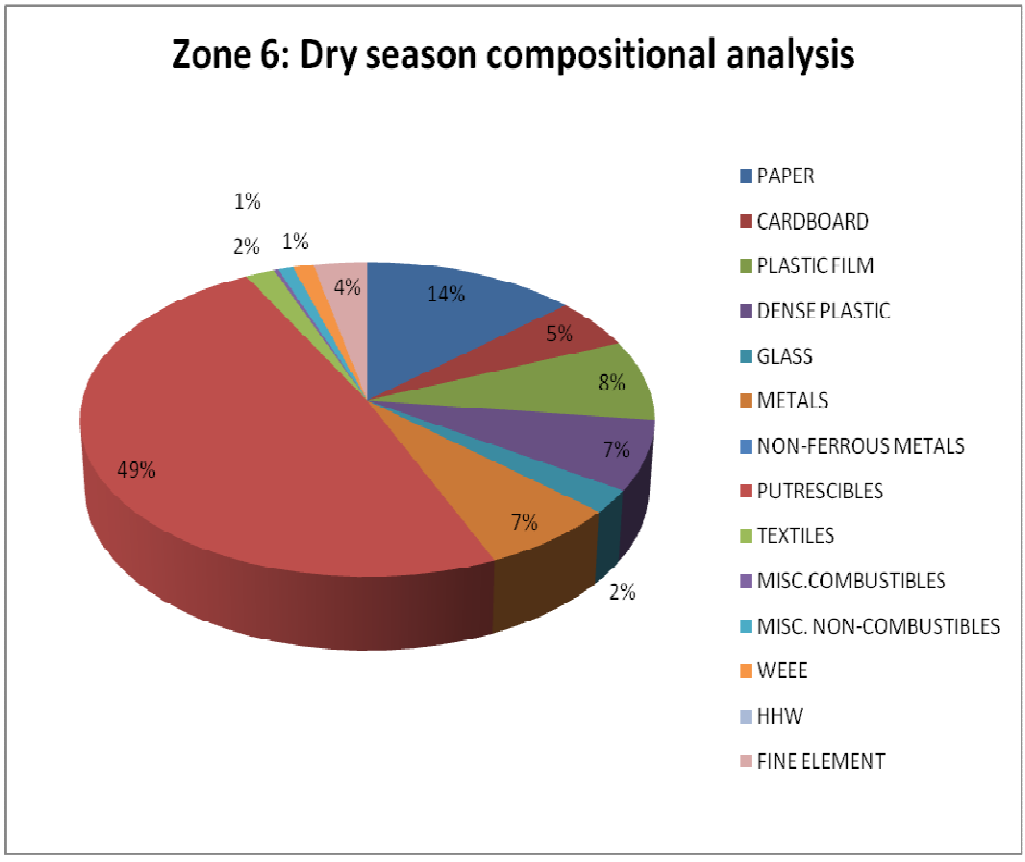

Figure 4.11: Composition of dry season sample from zone 6.

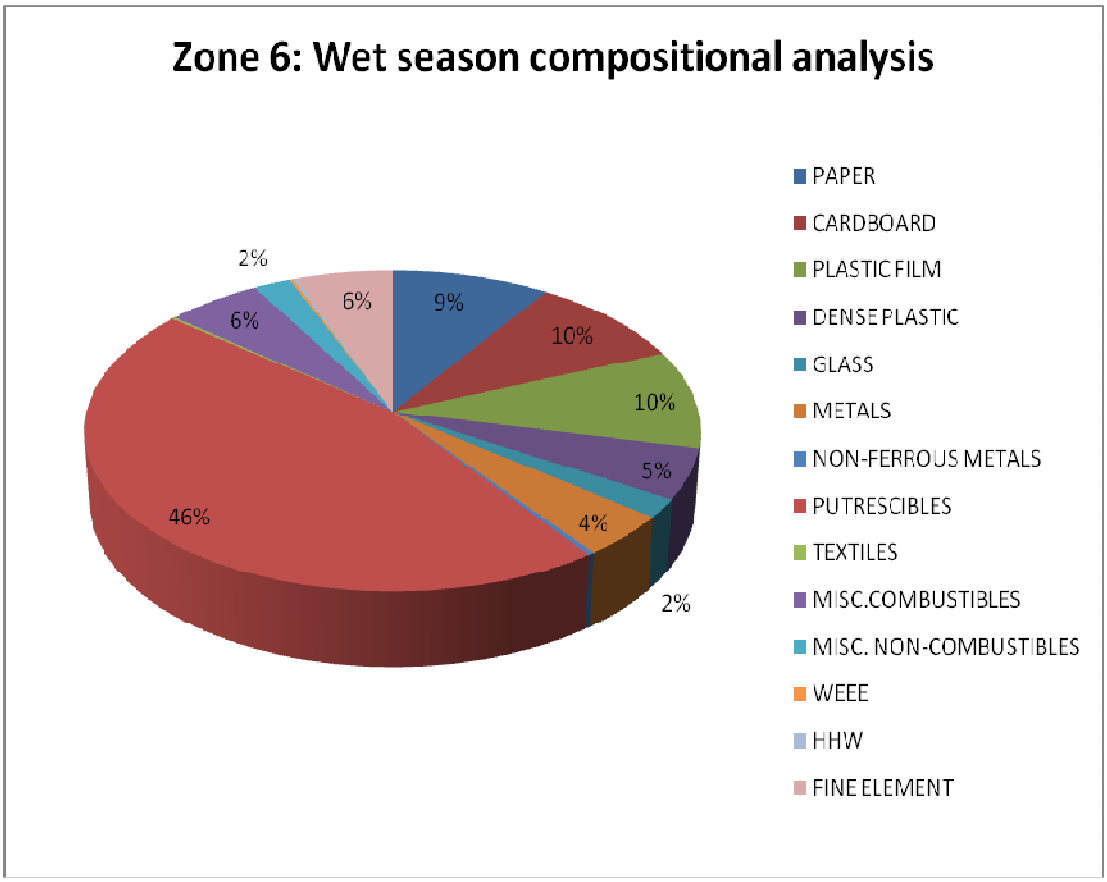

Figure 4.12: **Composition of wet season sample from zone 6.**

4.4.7: Results of MSW Composition Analysis in Zone 7

Samples from this zone were collected mainly from Central Bank of Nigeria staff quarters, Garki II. This low density neighbourhood has a predominance of high income households interspersed by some commercial presence. Figure 4.13 shows MSW composition analysis of dry season sample collected from the zone. From these graphs, the main components of the waste stream in the dry season were putrescibles (51%), cardboard (14%), plastic film (9%), paper (6%), dense plastic (5%), fine elements (4%) and glass (3%). These values compare favourably with those obtained from zone 6, another high income neighbourhood during the same period. The possible exception being the quantity of cardboard in the waste stream that varied by as much as 8% between the seasons. The prepondarance of paper and other industrial products in samples from this area is believed to reflect the consumption pattern of high income households with the wherewithal to purchase expensive processed products such as electronics and tinned food (Buenrostro *et al.*, 2001; Afroz *et al.*, 2009). Against the trend, there is a noticeable decline in the quantity of putrescibles during the wet season from 50%

recorded in the dry season to just under 44% (see Figure 4.14). This could well suggest evidence of seasonal shifts in consumption pattern amongst certain socio-economic groups in Abuja, were document in literature in studies on Kenya and Mexico (Syagga, 1992; Maldonado, 2006).

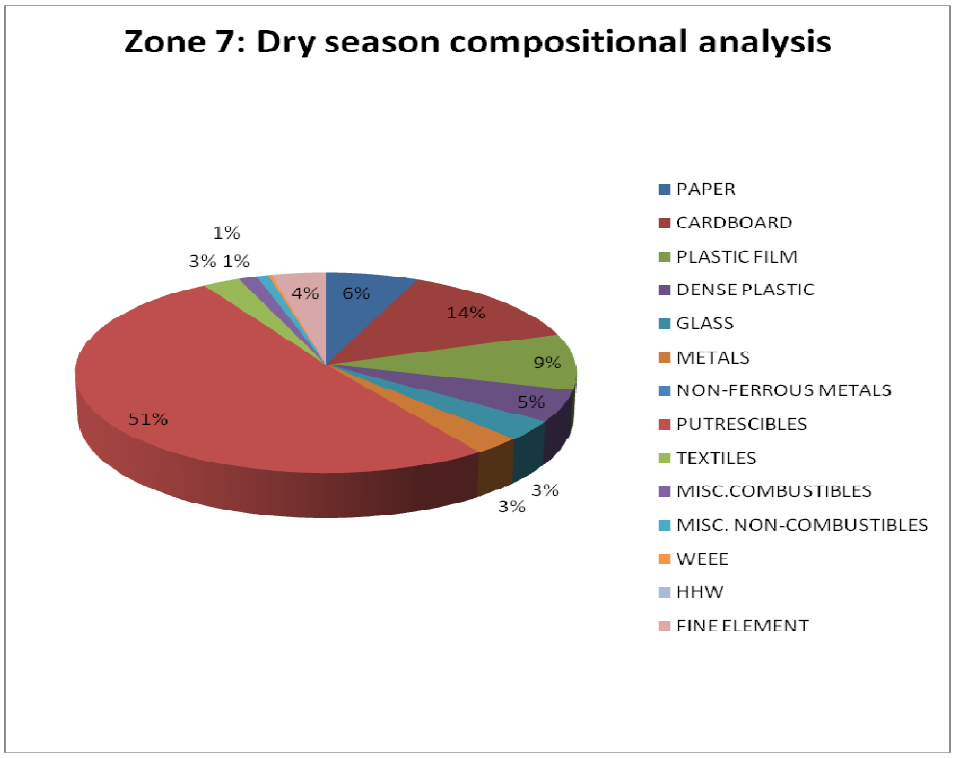

Figure 4.13: **Composition of dry season sample from zone 7.**

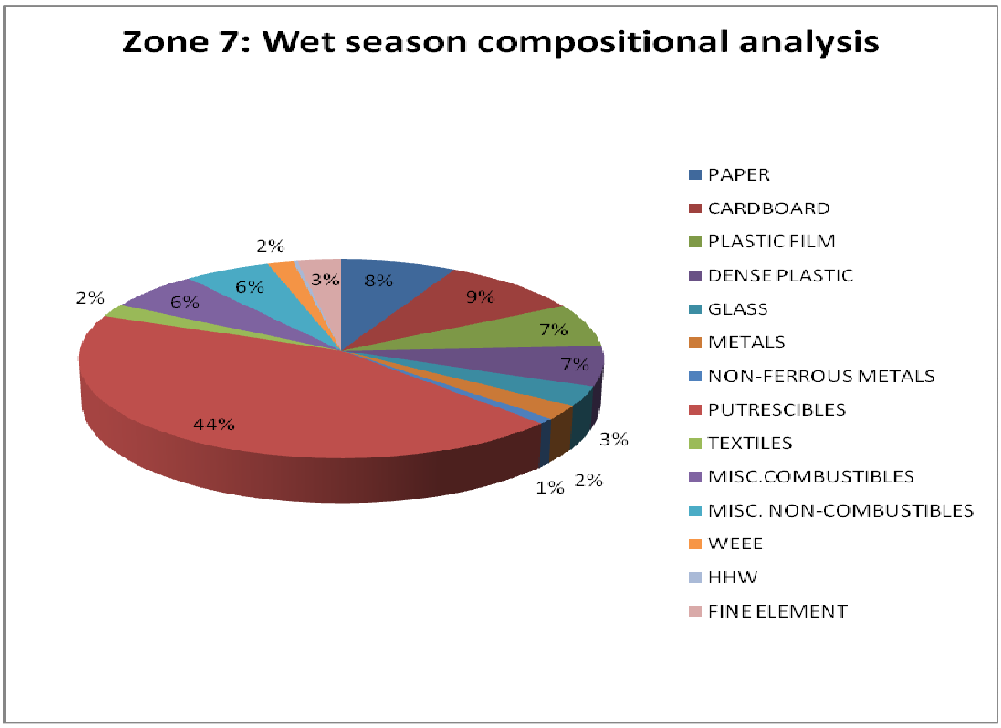

Figure 4.14: **Composition of wet season sample from zone 7.**

The quantity of cardboard in the wet season sample also decreased from 13% to 9%. Plastic films also reduced to 7% from dry season figures of 9%. In absolute terms, this value is significantly lower than values obtained from households in poorer neighbourhoods such as zone 4 (19%) and zone 5 (16%). This is in line with the findings of Grodzinska-Jurczak (2003) in an investigation on the relationship between education, knowledge and action for better waste management in Poland. This reduction is paid off for by slight increases in other material components which are mostly within the reach of higher income families such as bottled water (McCarthy, 1993). As such, there is a slight increase in the quantity of dense plastics from 5% in zone 4 (a low income neighbourhood) to 7% in this zone. Other key changes in the composition of the waste stream during this time include paper, which marginally increased from 6% in the dry season to 8% in the wet season, dense plastics (7%), miscellaneous combustibles (6%) and miscellaneous non-combustibles (6%).

4.4.8: Results of MSW Composition Analysis Zone 8

Samples from this zone were collected mainly from Gimbiya Street area in Garki II. This medium density neighbourhood has approximately equal proportions of high to medium income households. Figures 4.15 and 4.16 represent MSW composition analysis of dry and wet seasons samples collected from zone 8. From Figure 4.15, the main components of the waste stream in the dry season were putrescibles (41%), plastic film (15%), cardboard (11%), fine elements (11%), dense plastics (6%), paper (5%), and glass (4%). These values differ appreciably from those obtained during the same period in zone 7, a predominantly high income neighbourhood, suggesting a link between household income levels and waste composition (Wilson, 2007). The percentage of paper and other industrial products in samples from this area is consistent with values obtained from other medium to high income neighbourhoods (Osibanjo and Nnorom, 2009). There is however a noticeable increase in the quantity of putrescibles during the wet season from 43% recorded in the dry season to about 59% underlining the influence of seasonal dynamics on waste composition (Trankler *et al.*, 2005). During the same period however, the quantities of plastic films, cardboard, dense plastic and fine elements in the samples reduced to 9%, 8%, 4% and 1%, respectively, while paper increased marginally from 5% to 7%.

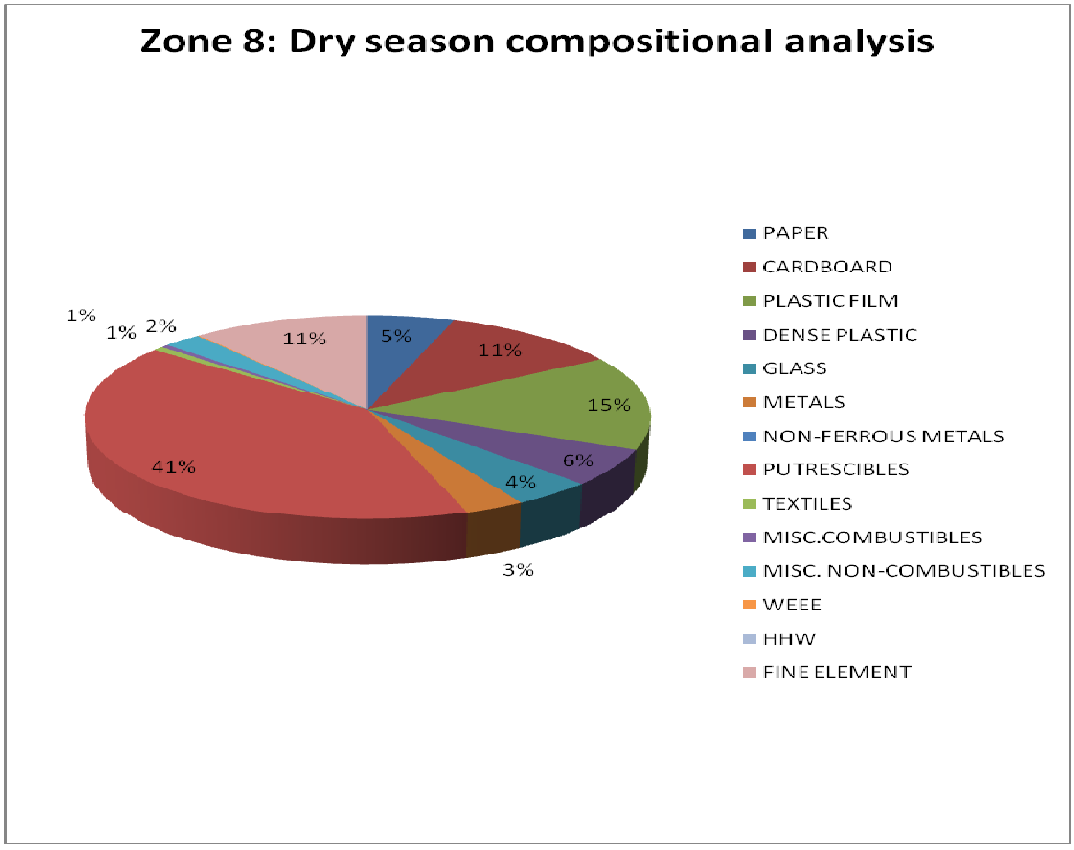

Figure 4.15: Composition of dry season sample from zone 8.

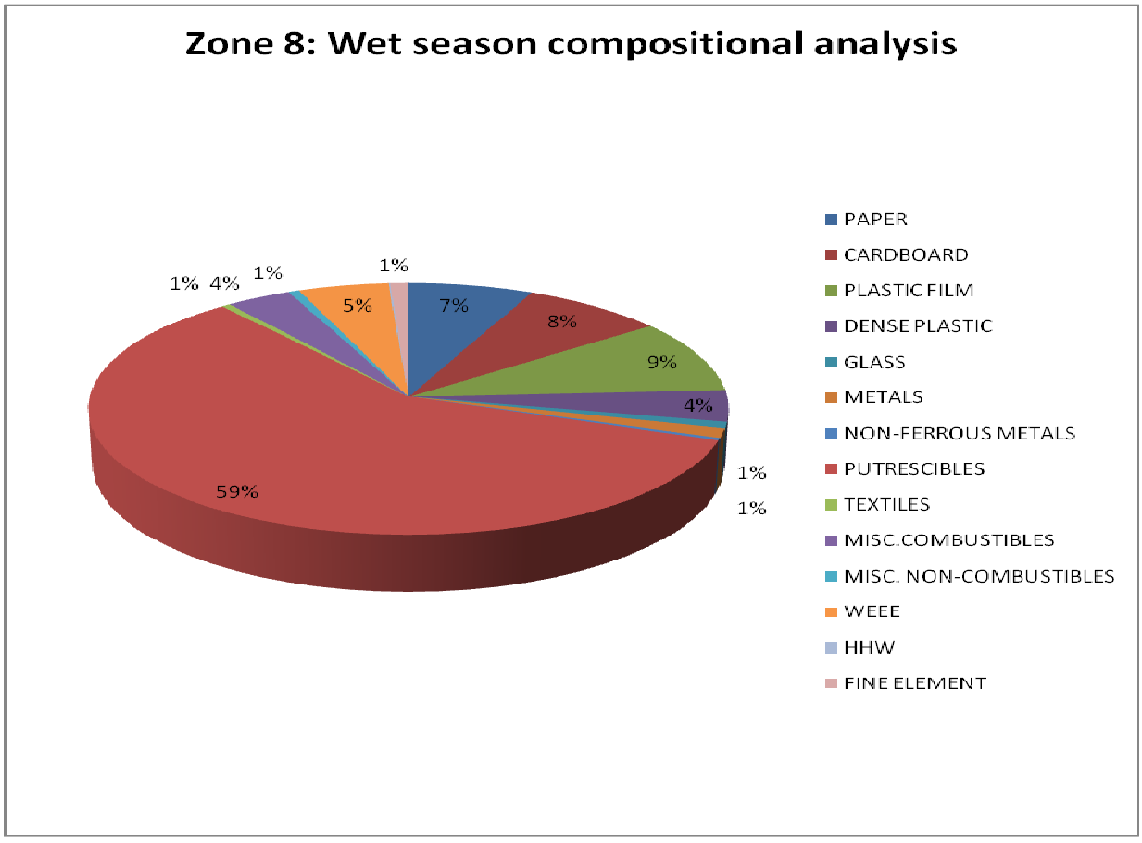

Figure 4.16: Composition of wet season sample from zone 8.

4.4.9: Summary: Dry Season Composition of MSW Samples

Figures 4.17, 4.18 and Table 4.2 represent a composite analysis of all dry season MSW samples taken from zones 1- 8. From the the graphs, the main components of dry season waste samples could be summarized as: putrescibles (47%), plastic film (12%), cardboard (9%), paper (7%), dense plastic (7%), fine elements (5%), glass (4%) and metals and cans 3%. The other components constitute just about 5% of the entire weight of sample. From the above statistics it could be seen that about 65% of the dry season waste sample from Abuja is biodegradable, mostly comprising of high wet weight and high moisture content kitchen wastes. These values are similar to the findings of Igoni *et al.* (Igoni *et al.*, 2007) in a similar study on Port Harcourt, Nigeria. On the other hand, the outstanding 35% of the dry season sample comprises mostly of non-degradable but recyclable materials such as glass, metals and cans, non ferrous metals and waste electrical and electronic equipment (WEEE). This implies that despite the dense, wet and highly biodegradable nature of the waste samples, there is a significant amount of other recyclable materials in the waste stream (Imam *et al.*, 2008).

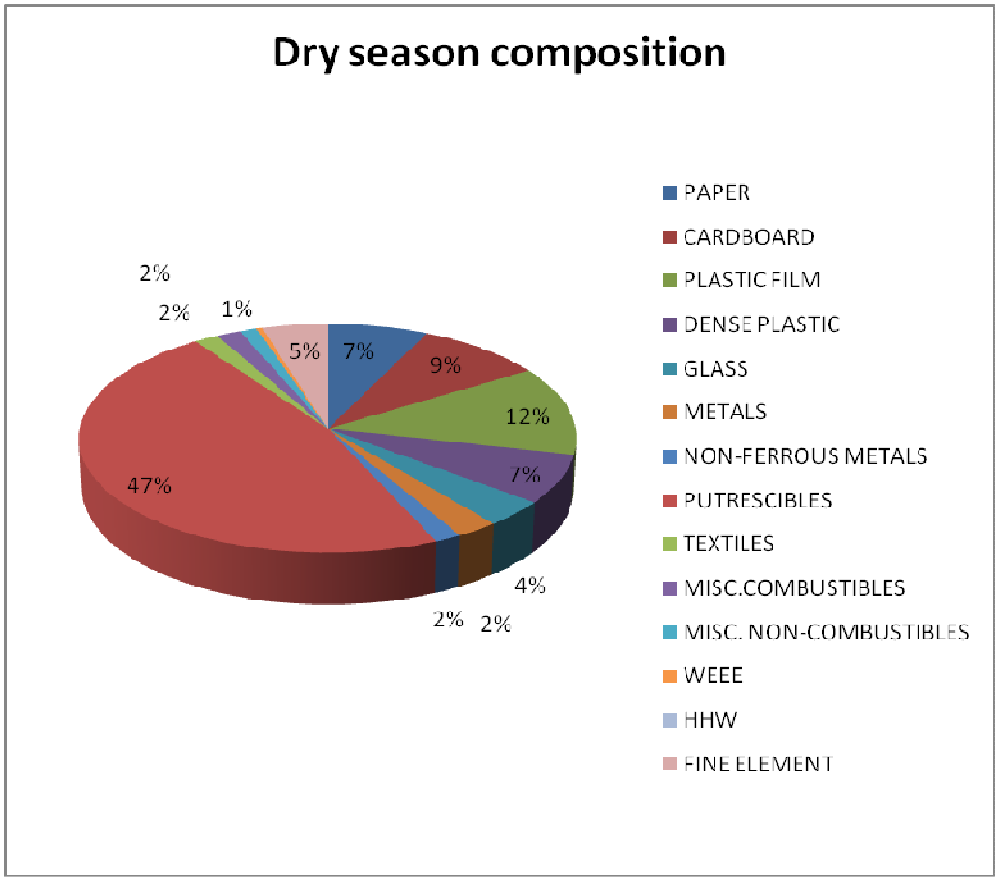

Figure 4.17: Summarised dry season MSW composition.

Table 4.2: Composition of dry season waste samples from zones 1-8

	Percentage composition by sampling zones								
Material classification	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Overall Mean
Paper	3.2	5.3	6.0	7.0	9.7	13.4	6.4	5.3	7.0
Cardboard	5.5	10.0	10.1	11.4	5.2	5.2	13.4	10.9	9.0
Plastic film	7.8	8.8	16.6	18.6	16.0	8.2	9.0	14.8	12.5
Dense plastic	4.0	11.8	2.4	5.2	13.9	7.1	5.1	5.8	6.9
Glass	2.7	2.6	3.6	4.7	6.5	2.4	3.2	4.2	3.7
Metals	1.0	2.1	1.1	1.5	1.6	6.9	2.9	3.1	2.5
Non-ferrous metals	0.0	0.0	8.8	4.2	0.0	0.0	0.0	0.0	1.6
Putrescibles	65.1	44.0	42.3	40.2	42.6	48.3	50.4	40.3	46.7
Textiles	0.5	0.9	3.3	2.2	1.5	1.8	2.6	0.6	1.7
Misc-combustibles	4.0	5.6	0.0	1.5	0.1	0.3	1.3	0.5	1.8
Misc. non-combustibles	2.6	2.3	0.0	0.0	0.9	1.0	0.8	2.3	1.2
WEEE	0.8	0.3	0.0	0.1	0.1	1.3	0.2	0.1	0.2
HHW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fine elements	2.5	6.0	5.6	2.9	1.6	3.4	3.7	10.7	4.6
Total	**99.7**	**99.5**	**99.6**	**99.4**	**99.7**	**99.1**	**98.9**	**98.7**	**99.4**

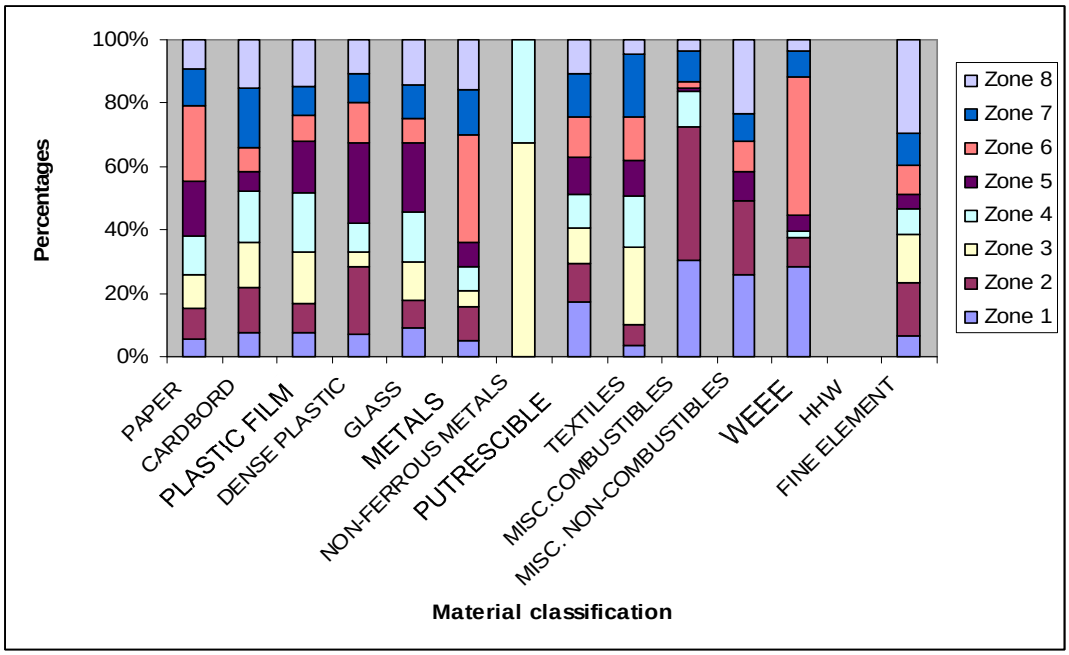

Figure 4.18: Composition of dry season waste samples from Zones 1-8.

4.4.10: Summarized Wet season Composition of MSW Samples

Figure 4.19, 4.20 and Table 4.3 represent a composite analysis of all wet season MSW samples taken from zones 1- 8. From the graphs, the main components of wet season waste samples could be summarized as: putrescibles (49%), plastic film (11%), cardboard (8%), paper (7%), dense plastic (4%), fine elements (4%), glass (2%) and metals and cans (4%)%. The other components constitute about 11% of the entire weight of sample. From the above statistics it could be seen that about 70% of the wet season waste sample from Abuja is biodegradable, mostly comprising high wet weight and moisture content kitchen wastes. On the other hand, the outstanding 30% of the dry season sample comprises mostly of non-degradable but recyclable materials such as glass, metals and cans, non ferrous metals and waste electrical and electronic equipment (WEEE).

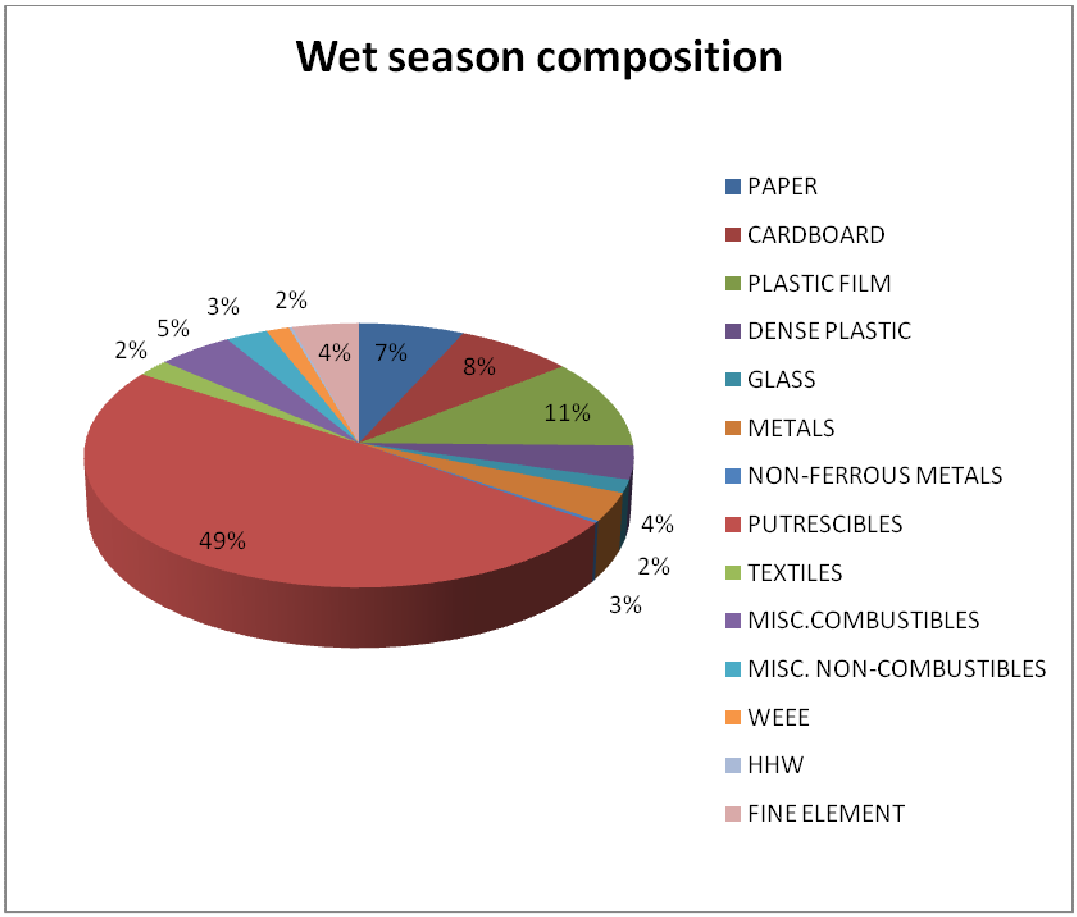

Figure 4.19: Summarised wet season MSW composition.

4.4.11: Seasonal Comparison of MSW Composition

Table 4.4 is a comparison of overall MSW composition during the dry and wet seasons. Aside from the household hazardous waste category where no data were captured, paper and textiles were the only categories that did not vary over the two seasons. There was a slight drop in the quantity of cardboard in the waste stream in the wet season (8%) as compared to dry season (9%). Similarly plastic film, dense plastic, glass, non-ferrous metals and fine elements dropped from 13%, 7%, 4%, 2% and 5% in the dry season to 11%, 4%, 2%, 0%, 4% respectively, in the wet season. On the other hand metals, putrescibles, miscellaneous combustibles, miscellaneous non-combustibles and waste electrical electronics increased from 3%, 47%, 2%, 1% and 0%, in the dry season to 4%, 50%, 5%, 3% and 2%, respectively, in the wet season.

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Table 4.3: Composition of wet season waste samples from zones 1-8

	Percentage composition by sampling zones								
Material classification	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Overall Mean
Paper	5.5	6.8	5.3	7.1	5.4	9.3	7.7	6.9	6.8
Cardboard	4.9	8.9	5.7	7.7	7.1	9.4	9.5	7.9	7.6
Plastic film	14.9	13.5	9.8	9.7	13.4	9.9	7	9.3	10.9
Dense plastic	2.3	3.2	2.7	3.6	4.8	5.1	6.6	4.1	4.1
Glass	2.7	0	1.4	1.6	1.4	1.9	3.2	0.8	1.6
Metals	7.9	7.2	1.7	1.5	2.1	4.3	2.3	1.2	3.5
Non-ferrous metals	0.7	0.1	0.1	0.2	0	0.3	0.9	0.3	0.3
Putrescibles	49.9	51.8	56	45.9	44.1	45.7	43.6	58.7	49.5
Textiles	0.7	3.1	4.8	2.4	2.7	0.2	2.1	0.5	2.1
Misc-combustibles	4.6	1	4.7	11.2	2.5	5.6	6.3	3.6	4.9
Misc. non-combustibles	0.9	0.3	2.1	1.5	7.8	2.2	5.8	0.6	2.7
WEEE	0.8	2.5	1	0.3	0.5	0.2	1.7	5	1.5
HHW	0.1	0	0.3	0	0.4	0.2	0.3	0.1	0.2
Fine elements	4.1	1.5	4.5	7.2	7.7	5.7	2.9	1	4.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

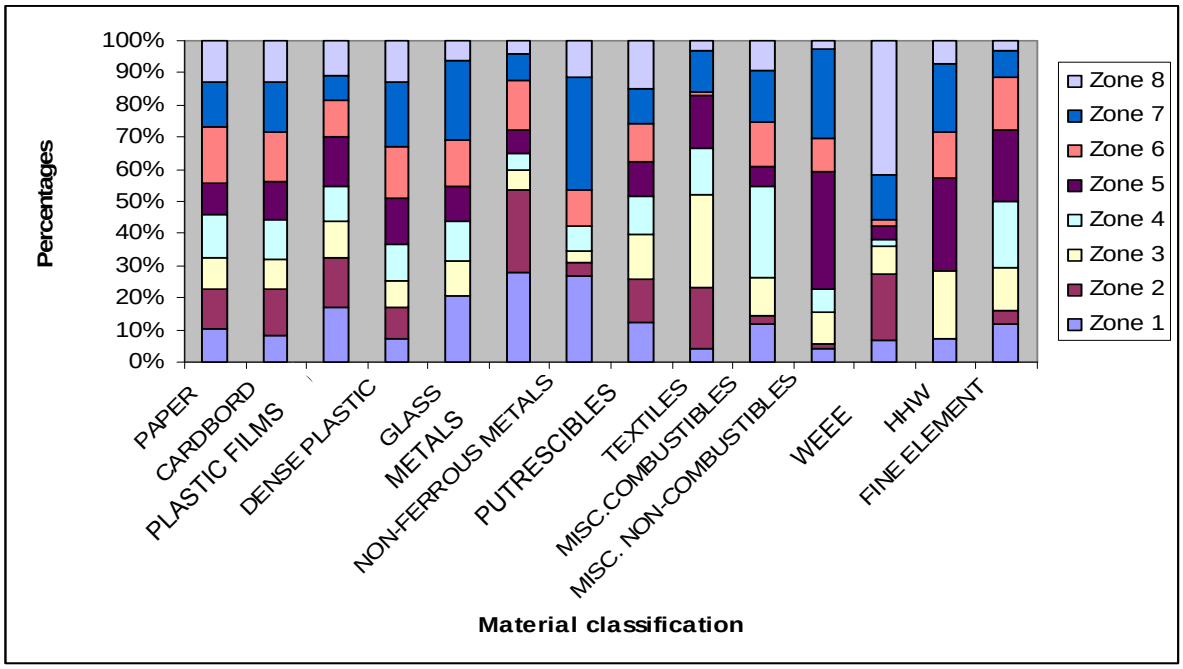

Figure 4.20: Composition of wet season waste samples from Zones 1-8.

Table 4.4: Comparison of MSW composition in dry and wet seasons

Material classification	Dry season composition	Wet season composition
Paper	7	7
Cardboard	9	8
Plastic film	13	11
Dense plastic	7	4
Glass	4	2
Metals	3	4
Non-ferrous metals	2	0
Putrescibles	47	50
Textiles	2	2
Misc.combustibles	2	5
Misc. Non-combustibles	1	3
WEEE	0	2
HHW	0	0
Fine elements	5	4
TOTAL	**99**	**100**

4.5: Statistical Test of Variance in MSW Composition

To further explore the relationship between waste stream compositional data obtained during the dry and wet seasons, a statistical analysis was undertaken using SPSS for Windows Version 16. Statistical analysis became necessary because although, initial analysis using Microsoft excel for windows discovered some variations in the composition of the samples both within the sampling zones as well as across seasons, it was necessary to check whether these variations were statistically significant or indeed where they actually occurred. Equally, further statistical analysis yielded more robust data which underpins prescribed management strategies. This is necessary because there is currently a dearth of empirical data, derived through a rigorous analytical process on waste composition in Nigeria and other SSA countries.

4.5.1: ANOVA Results for Seasonal Variation in Sample Composition.

A one way ANOVA was used to test the effect of seasonal variations on sample composition. This technique was used because one way Analysis of Variance (ANOVA) allows one to test if the means being compared are different (varied) from each other. One way ANOVA was particularly useful in this comparison because it could compare means irrespective of whether the dependent variable was an interval or ordinally scaled data.

4.5.1.1: Descriptive Statistics

Appendix 4 is a table of descriptive statistics of the fourteen material categories. From this table, mean values, standard deviation, standard error, 95% confidence interval for means at lower and upper boundaries as well as maximum and minimum values for each of the material categories can be obtained. The total number of samples analysed (N), for both the dry and wet seasons was 160**.**

4.5.1.2: Analysis of Variance

Analysis of variance on the effect of seasonal variations on sample composition was based on an initial hypothetical premise as summarized by the following null hypothesis:

Null hypothesis H_o: That the mean values of material components in the samples were the same in the dry and wet seasons.

ANOVA test results from Table 4.5 however showed that the means of four material components, dense plastics, glass, miscellaneous combustibles and Household Hazardous Waste (HHW) differed or varied significantly in the dry season as compared to the wet season figures. Null hypothesis H_o is thus rejected and the alternate hypothesis H_1 that the means of certain component of the samples varied significantly is retained. This variation is calculated as the ratio of mean square deviation between seasons and within season, otherwise known as the (F) statistic. The extent or how significant (insignificant) the calculated variation is reflected by the value of the (P) statistic; where $P \leq 0.05$, level of variation is said to be statistically significant.

From Table 4.5, there was a significant main effect of season on:

Dense plastic {F (1, 158) = 5.205: P = 0.024}. This indicates that there was more dense plastics in the waste stream in the dry season than wet season.

Glass {F (1, 158) = 4.749: P = 0.031}. This indicates that there was more glass in the waste stream in the dry season than the wet season.

Miscellaneous combustibles {F (1, 158) = 8.481: P = 0.004}. This indicates that there were more miscellaneous combustibles in the waste stream in the wet season than the dry season.

HHW {F (1, 158) = 7.715: P = 0.006}. This indicates that there was more Hazardous Household Waste (HHW) in the waste stream in the wet season than the dry season.

WEEE showed a weak variation at {F (1,158) = 3.830: P = 0.052}

Significance values (P), in this case is a two tailed probability that the magnitude of the test statistic is a chance result. A confidence level of 0.05 (95%) is assumed throughout this thesis. Where $P < 0.05$, this indicates a 95% confidence level that perceived variation is not by chance or error.

The remaining nine components, paper, cardboard, plastic films, metals, non-ferrous metals, putrescibles, textiles, miscellaneous non-combustibles and fine elements had no significant statistical variations over the seasons or instances of variation could be ascribed to chance occurrence.

Table 4.5: ANOVA test results for seasonal variation in MSW composition

Material		Sum of Squares	df	Mean Square	F	Sig (P)
PAPER	Between groups	2.935	1	2.935	0.051	0.821
	Within groups	9041.905	158	57.227		
	Total	9044.840	159			
CARDBOARD	Between groups	60.725	1	60.725	0.869	0.353
	Within groups	11035.375	158	69.844		
	Total	11096.100	159			
PLASTIC FILM	Between groups	91.355	1	91.355	1.180	0.279
	Within groups	12232.988	158	77.424		
	Total	12324.343	159			
DENSE PLASTIC	Between groups	322.652	1	322.652	5.205	0.024
	Within groups	9793.820	158	61.986		
	Total	10116.472	159			
GLASS	Between groups	179.649	1	179.649	4.749	0.031
	Within groups	5976.800	158	37.828		
	Total	6156.449	159			
METALS	Between groups	40.875	1	40.875	0.784	0.377
	Within groups	8240.320	158	52.154		
	Total	8281.195	159			
NON-FERROUS METALS	Between groups	66.822	1	66.822	1.441	0.232
	Within groups	7328.247	158	46.381		
	Total	7395.070	159			
PUTRESCIBLES	Between groups	321.659	1	321.659	0.728	0.395
	Within groups	69802.641	158	441.789		
	Total	70124.300	159			
TEXTILES	Between groups	6.569	1	6.569	0.359	0.550
	Within groups	2889.156	158	18.286		
	Total	2895.725	159			
MISC-COMBUSTIBLES	Between groups	432.208	1	432.208	8.481	0.004
	Within groups	8051.879	158	50.961		
	Total	8484.087	159			
MISC NON-COMBUSTIBLES	Between groups	79.270	1	79.270	2.347	0.128
	Within groups	5336.414	158	33.775		
	Total	5415.685	159			
WEEE	Between groups	50.636	1	50.636	3.830	0.052
	Within groups	2088.808	158	13.220		
	Total	2139.444	159			
HHW	Between groups	1.173	1	1.173	7.715	0.006
	Within groups	24.024	158	.152		
	Total	25.197	159			
FINE ELEMENTS	Between groups	2.214	1	2.214	0.020	0.887
	Within groups	17236.198	158	109.090		
	Total	17238.412	159			

4.5.1.3: Test of Homogeneity

Results for this test are presented in Table 4.6. The Levene statistic is designed to test the null hypothesis that the variances of the groups are the same. In this case, the Levene statistic is testing whether the variances between the seasons are the same. Where the Levene statistic is significant (i.e. <0.05), it is concluded that the variances are significantly different; thus it will be required to rectify the differences between the group variances by transforming the data. In such instance the post-hoc tests that do not assume normality of data would be preferred. From Table 4.6, there is significant variations at dense plastic, P <0.001; glass, P <0.002; non-ferrous metals, P <0.01; miscellaneous combustibles, P ≤0.001; miscellaneous non combustibles, P <0.022; WEEE, P <0.007 and HHW, P ≤0.001.

Table 4.6: Test of homogeneity results for seasonal variation in MSW composition

Material	Levene Statistic	df1	df2	Sig.
Paper	1.695	1	158	0.195
Cardboard	0.476	1	158	0.491
Plastic film	2.910	1	158	0.090
Dense plastic	**11.538**	**1**	**158**	**<0.001**
Glass	**10.077**	**1**	**158**	**0.002**
Metals	1.453	1	158	0.230
Non-ferrous metals	**6.788**	**1**	**158**	**0.010**
Putrescibles	2.506	1	158	0.115
Textiles	0.748	1	158	0.388
Misc-combustibles	**15.638**	**1**	**158**	**<0.001**
Misc non-combustibles	**5.362**	**1**	**158**	**0.022**
WEEE	**7.572**	**1**	**158**	**0.007**
HHW	**29.106**	**1**	**158**	**<0.001**
Fine elements	0.682	1	158	0.410

4.5.2: ANOVA Results for Effect of Sampling Zones on Sample Composition

A one way ANOVA was used to test the effect of sampling zone on sample composition.

4.5.2.1: Descriptive Statistics

Appendix 5 is a table of descriptive statistics of the fourteen material categories. From this table, mean values, standard deviation, standard error, 95% confidence interval for means at

lower and upper boundaries as well as maximum and minimum values for each of the material categories can be obtained. The total number of samples analysed N, for both the dry and wet seasons was 160.

4.5.2.2: Analysis of Variance

Analysis of variance on the effect of residential zones on sample composition was based on an initial hypothetical premise as summarized by the following null hypothesis:

Null hypothesis H_o: That the mean values of material components of waste samples were the same in all the sampling zones

ANOVA test results in Table 4.7 shows that there was no significant difference in the mean values of material components across the eight sampling zones.

The null hypothesis H_o that the mean values for individual material components in the samples did not vary significantly both within and across the sampling zones is retained. Probable explanation for this situation could be that consumption patterns amongst the resident of Abuja do not vary significantly.

4.5.2.3: Post-Hoc Test

Post-hoc tests found no significant difference between the means of material components in the waste samples both within and between the sampling zones. Appendix 6 (enclosed as a compact disc) is results of a post-hoc test for effect of sampling zones and sample composition.

Table 4.7: ANOVA test results for spatial variation in MSW composition

Material		Sum of Squares	df	Mean Square	F	Sig (P)
PAPER	Between groups	593.635	7	84.805	1.525	0.163
	Within groups	8451.205	152	55.600		
	Total	9044.840	159			
CARDBOARD	Between groups	611.290	7	87.327	1.266	0.271
	Within groups	10484.810	152	68.979		
	Total	11096.100	159			
PLASTIC FILM	Between groups	765.895	7	109.414	1.439	0.194
	Within groups	11558.448	152	76.042		
	Total	12324.343	159			
DENSE PLASTIC	Between groups	703.052	7	100.436	1.622	0.133
	Within groups	9413.420	152	61.930		
	Total	10116.472	159			
GLASS	Between groups	89.799	7	12.828	0.321	0.943
	Within groups	6066.650	152	39.912		
	Total	6156.449	159			
METALS & CANS	Between groups	377.264	7	53.895	1.036	0.408
	Within groups	7903.931	152	52.000		
	Total	8281.195	159			
NON-FERROUS METALS	Between groups	343.896	7	49.128	1.059	0.393
	Within groups	7051.174	152	46.389		
	Total	7395.070	159			
PUTRESCIBLES	Between groups	2838.007	7	405.430	0.916	0.496
	Within groups	67286.293	152	442.673		
	Total	70124.300	159			
TEXTILES	Between groups	183.642	7	26.235	1.470	0.182
	Within groups	2712.083	152	17.843		
	Total	2895.725	159			
MISC-COMBUSTIBLES	Between groups	345.780	7	49.397	0.923	0.491
	Within groups	8138.307	152	53.541		
	Total	8484.087	159			
MISC NON-COMBUSTIBLES	Between groups	215.792	7	30.827	0.901	0.507
	Within groups	5199.893	152	34.210		
	Total	5415.685	159			
WEEE	Between groups	81.359	7	11.623	0.858	0.541
	Within groups	2058.085	152	13.540		
	Total	2139.444	159			
HHW	Between groups	0.690	7	0.099	0.612	0.746
	Within groups	24.506	152	0.161		
	Total	25.197	159			
FINE ELEMENTS	Between groups	116.905	7	16.701	0.148	0.994
	Within groups	17121.507	152	112.641		
	Total	17238.412	159			

4.5.2.4: Test of Homogeneity

Results for this test are presented in Table 4.8. The Levene statistic is designed to test the null hypothesis that the variances of the groups are the same. In this case, the Levene statistic is testing whether the variances between the zones are the same. Where the Levene statistic is significant (i.e. <0.05), we conclude that the variances are significantly different; thus it will be required to rectify the differences between the group variances by transforming the data. In such instance a post-hoc test that does not assume normality of data would be preferred. From Table 4.8, there is significant variations at Paper, P <0.008; dense plastic, P <0.005; non-ferrous metals, P ≤0; textiles, P <0.001; miscellaneous non-combustibles, P <0.018; WEEE, P <0.005 and HHW, P <0.018.

Table 4.8: **Test of homogeneity results for spatial variation in MSW composition**

Material	Levene Statistic	df1	df2	Sig.
Paper	**2.845**	**7**	**152**	**0.008**
Cardboard	1.155	7	152	0.332
Plastic film	1.366	7	152	0.223
Dense plastic	**3.064**	**7**	**152**	**0.005**
Glass	1.153	7	152	0.333
Metals	1.919	7	152	0.070
Non-ferrous metals	**4.366**	**7**	**152**	**<0.001**
Putriscibles	0.676	7	152	0.692
Textiles	**3.846**	**7**	**152**	**<0.001**
Misc-combustibles	2.052	7	152	0.052
Misc non-combustibles	**2.524**	**7**	**152**	**0.018**
WEEE	**3.023**	**7**	**152**	**0.005**
HHW	**2.518**	**7**	**152**	**0.018**
Fine elements	0.473	7	152	0.853

4.5.3: ANOVA Results for Effect of Household Income on Sample Composition.

One way ANOVA was used to test the effect of household income on sample composition.

4.5.3.1: Descriptive Statistics

Appendix 7 is a table of descriptive statistics of the fourteen material categories. From this table, mean values, standard deviation, standard error, 95% confidence interval for means at lower and upper boundaries as well as maximum and minimum values for each of the material categories can be obtained. The total number of samples analysed N, for both the dry and wet seasons was 160.

4.5.3.2: Analysis of Variance

Analysis of variance on the effect of changes in household income on sample composition was based on an initial hypothetical premise as summarised by the following null hypothesis

Null hypothesis H_o: That the mean values of material components in the samples were the same amongst all income groups

ANOVA test results from Table 4.9 however showed that the mean values of four material components, paper, cardboard, plastic films and Putrescibles differed or varied significantly across household income groups. Null hypothesis H_o is thus rejected and the alternate hypothesis H_1 that the mean values of some components in the sample varied across income groupings is hence retained. This variation is reflected as the ratio of mean square deviation between income groups and within income groups, otherwise known as the (F) statistic.

From Table 4.9, there is a significant main effect of income group on:

Paper {$F(3, 156) = 12.771$: $P < 0.001$}.

Cardboard {$F(3, 156) = 6.382$: $P < 0.001$}.

Plastic film {$F(3, 156) = 3.002$: $P = 0.032$}.

Putrescibles {$F(3, 156) = 4.917$: $P = 0.003$}.

The remaining ten components, dense plastics, glass, metals, non-ferrous metals, textiles, miscellaneous combustibles, miscellaneous non-combustibles, WEEE, HHW and fine elements showed no significant statistical variations amongst the income groups or instances of variation could be ascribed to chance occurrence.

Table 4.9: ANOVA test results for interaction between income levels and MSW composition

Material		Sum of Squares	df	Mean Square	F	Sig (P)
PAPER	Between groups	1783.368	3	594.456	12.771	<0.001
	Within groups	7261.472	156	46.548		
	Total	9044.840	159			
CARDBOARD	Between groups	1212.912	3	404.304	6.382	<0.001
	Within groups	9883.188	156	63.354		
	Total	11096.100	159			
PLASTIC FILM	Between groups	672.676	3	224.225	3.002	0.032
	Within groups	11651.667	156	74.690		
	Total	12324.343	159			
DENSE PLASTIC	Between groups	376.343	3	125.448	2.009	0.115
	Within groups	9740.130	156	62.437		
	Total	10116.472	159			
GLASS	Between groups	166.851	3	55.617	1.449	0.231
	Within groups	5989.598	156	38.395		
	Total	6156.449	159			
METALS	Between groups	67.530	3	22.510	0.428	0.734
	Within groups	8213.665	156	52.652		
	Total	8281.195	159			
NON-FERROUS METALS	Between groups	52.030	3	17.343	0.368	0.776
	Within groups	7343.040	156	47.071		
	Total	7395.070	159			
PUTRESCIBLES	Between groups	6058.053	3	2019.351	4.917	0.003
	Within groups	64066.247	156	410.681		
	Total	70124.300	159			
TEXTILES	Between groups	34.246	3	11.415	0.622	0.602
	Within groups	2861.479	156	18.343		
	Total	2895.725	159			
MISC-COMBUSTIBLES	Between groups	43.788	3	14.596	0.270	0.847
	Within groups	8440.299	156	54.104		
	Total	8484.087	159			
MISC NON-COMBUSTIBLES	Between groups	19.857	3	6.619	0.191	0.902
	Within groups	5395.827	156	34.589		
	Total	5415.685	159			
WEEE	Between groups	72.972	3	24.324	1.836	0.143
	Within groups	2066.472	156	13.247		
	Total	2139.444	159			
HHW	Between groups	.382	3	0.127	0.801	0.495
	Within groups	24.815	156	0.159		
	Total	25.197	159			
FINE ELEMENTS	Between groups	27.991	3	9.330	0.085	0.968
	Within groups	17210.421	156	110.323		
	Total	17238.412	159			

4.5.3.3: Post-Hoc Test

A post-hoc test to determine how the means for the components that showed significant variations differed is attached as Appendix 8. Table 4.10 outlines points of significant variations from the results of test of effect of changes in income levels on sample composition.

Table 4.10: **Extract from post-hoc test showing points of significant variations**

Dependent Variable	(I) INC CLASS	(J) INC CLASS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound.	Upper Bound.
PAPER	low income	unspecified	-10.0339*	1.7979	<0.001	-14.703	-5.365
	medium income	unspecified	-9.3092*	1.6402	<0.001	-13.569	-5.050
	high income	unspecified	-8.0529*	1.7789	<0.001	-12.673	-3.433
CARDBOARD	unspecified	low income	10.0339*	1.7979	<0.001	5.365	14.703
		medium income	9.3092*	1.6402	<0.001	5.050	13.569
		high income	8.0529*	1.7789	<0.001	3.433	12.673
		unspecified	-8.8753*	2.0975	<0.001	-14.322	-3.428
	medium income	unspecified	-6.5807*	1.9135	0.004	-11.550	-1.611
PLASTIC FILM	low income	high income	5.9045*	2.0100	0.020	0.685	11.124
	high income	low income	-5.9045*	2.0100	0.020	-11.124	-.685
PUTRESCIBLES	low income	unspecified	16.6131*	5.3404	0.012	2.744	30.482
	medium income	unspecified	17.9828*	4.8719	0.002	5.331	30.635
	unspecified	low income	-16.6131*	5.3404	0.012	-30.482	-2.744
		medium income	-17.9828*	4.8719	0.002	-30.635	-5.331
		high income	-16.1175*	5.2839	0.014	-29.839	-2.396

4.5.3.4: Test of Homogeneity

Results for this test are presented in Table 4.11. The Levene statistic is designed to test the null hypothesis that the variances of the groups are the same. In this case, the Levene statistic is testing whether the variances between income classes are the same. Where the Levene statistic is significant (i.e. < 0.05), we conclude that the variances are significantly different; thus it will be required to rectify the differences between the group variances by transforming the data. In such instance a post-hoc test that does not assume normality of data would be

preferred. From Table 4.11, there is significant variations in Paper, P <0.001; glass, P <0.008; WEEE, P <0.001 and HHW, P <0.026.

Table 4.11: **Test of homogeneity results for interaction between income levels and MSW composition**

Material	Levene Statistic	df1	df2	Sig.
Paper	16.730	3	156	<0.001
Cardboard	2.197	3	156	0.091
Plastic film	1.567	3	156	0.200
Dense plastic	1.135	3	156	0.337
Glass	4.080	3	156	0.008
Metals	0.597	3	156	0.618
Non-ferrous metals	1.447	3	156	0.231
Putrescibles	0.562	3	156	0.641
Textiles	0.723	3	156	0.540
Misc-combustibles	0.248	3	156	0.863
Misc non-combustibles	1.027	3	156	0.382
WEEE	5.444	3	156	<0.001
HHW	3.166	3	156	0.026
Fine elements	0.376	3	156	0.770

4.6: Conclusions

The sampling area is largely a residential area interspersed with small businesses and a number of government offices, schools and churches. Population density ranges from low in Zone 7 to high in Zone 5. Income levels of residents also varied widely both within and across sampling zones. Maximum temperatures for Abuja during this study were in the range of 31-35°C and minimum temperature was in the range of 15-20°C. There were no rainfalls recorded during the duration of the dry season sampling. The period for the wet season sampling however coincided with the period for annual maximum rainfall. Analysis of rainfall anomaly by the Nigerian Meteorological Agency showed that Abuja recorded normal rainfall for these months. Relative humidity during the dry and wet season sampling periods averaged 21% and 73%, respectively.

Generally therefore, climatic conditions throughout the study period were stable and typical for the region. Proximate analysis of samples revealed moisture content of 58.5%. The implication of this level of moisture is that samples are not suitable for incineration but are ideal for composting and other mechanical and biological management options.

The main components of dry season waste samples could be summarized as: putrescibles (47%), plastic film (13%), cardboard (9%), paper (7%), dense plastic (7%), fine elements (5%), glass (4%) and metals 3%. The remaining components constitute just about 5% of the entire weight of sample. By inference, about 65% of the dry season waste sample is biodegradable, mostly comprising of high wet weight and high moisture content kitchen wastes. On the other hand, the main components of wet season waste samples are: putrescibles (50%), plastic film (11%), cardboard (8%), paper (7%), dense plastic (4%), fine elements (4%), glass (2%) and metals (4%). The remaining components constitute about 11% of the entire weight of sample. This implies that about 70% of the wet season waste sample is biodegradable, comprised mostly of high wet weight and moisture content putrecible components. On the other hand, the outstanding 30% of the wet season sample comprises mostly of non-degradable but recyclable materials such as glass, metals, non-ferrous metals and waste electrical and electonic equipment

ANOVA test results shows that the means of only four material components, dense plastics, glass, miscellaneous combustibles and Household Hazardous Waste (HHW) differed or varied significantly between the dry and wet seasons. In particular, there were more dense plastics in the waste stream in the dry season than wet season. Equally, there was more glass, in the waste stream in the dry season than the wet season. On the other hand, there was more miscellaneous combustibles and HHW in the waste stream in the wet season than the dry season while WEEE showed a weak variation between the two seasons. Paper, cardboard, plastic films, metals, non-ferrous metals, Putrescibles, textiles, miscellaneous non-combustibles and fine elements showed no significant statistical variations over the two seasons.

ANOVA test also shows that there were no significant variations in the means of material components both within and between the eight sampling zones. A probable explanation for this situation could be that consumption patterns amongst the residents of Abuja do not vary radically. ANOVA test results likewise shows that the means of four material components, paper, cardboard, plastic films and putrescibles differed significantly when compared against different household income groups. The remaining ten components: dense plastics, glass,

metals, non-ferrous metals, textiles, miscellaneous combustibles, miscellaneous non combustibles, WEEE, HHW and fine elements showed no significant statistical variations amongst these income groups.

4.7: Recommendations

This investigation thus finds the impact of seasonal, spatial and economic dynamics on the character of the municipal solid waste stream in Abuja to be quite limited. The quantity of bio-degradable materials and other key components of the waste stream did not vary significantly with seasonal changes. Given that the essential composition of the waste stream remained constant throughout the seasons and in most zones sampled, a unitary management strategy is recommended for MSW management in the City.

Approximately 60% of MSW samples from the City were found to be biodegradable materials ideal for compost production. Apart from the biodegradables, there are over 11% recyclable materials in the MSW waste stream. Informal sector recycling is currently the only form of recycling available in the City up taking approximately 3% of recyclable components and providing gainful employment to many. It is recommended to mainstream the operations of the informal sector in recycling with emphasis in compost production by providing opportunities for training in best practise, so as to enhance recycling rates in the City.

CHAPTER FIVE
QUESTIONNAIRE SURVEY

5.0 Introduction

This chapter presents the results of the questionnaire survey that was carried out between July and September 2008, to gather information on aspects of solid waste management in Abuja. The chapter is organized in sections covering: (i) Descriptive statistical results (ii) Results from analysis of nominal data (iii) Result from analysis of ordinal data (iv) Results from analysis of barriers affecting MSW management (v) Results from analysis of success factors affecting MSW management (vii) Conclusion and recommendations.

5.1: Descriptive statistical results

5.1.1: Outline of surveyed groups

Table 5.1 shows an outlines the number of Abuja households, businesses and waste policy makers surveyed during the main questionnaire survey. A total of 1,557 responses were returned by all three target groups surveyed. Of this number, 1204 responses, equivalent to 77.3% were from households, 200 responses (12.8%) were received from businesses, while 153 responses (9.8%) were received from waste policy makers.

Table 5.1: Outline of surveyed groups

	type of respondent	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Households	1204	77.3	77.3	77.3
	Businesses	200	12.8	12.8	90.2
	Policymakers	153	9.8	9.8	100.0
	Total	**1557**	**100.0**	**100.0**	

5.1.2 Results from pilot survey

As discussed in Chapter Three, an online format of the household questionnaire was adapted using the Surveyor sampling software. This online questionnaire was then mailed to 250 Nigerian students of the University of Wolverhampton via the University's International Students' office between June and July, 2008. A total of 57 responses were returned equivalent to about 23% response rate. Figures 5.1-5.4 are graphical representation of responses to key question in the pilot survey. From figure 5.1, it can be deduced that over 30% of respondents to the pilot survey reside in the satellite towns surrounding the City. This situation is explained by the fact that a significant proportion of low income earners who work in Abuja are unable to afford the cost of accommodation within the City and have to commute to and from work daily from the satellite towns around the City. Figure 5.2 shows that over 50% of respondents to the pilot survey describe themselves as comfortably – off, as opposed to about 5% who said they were wealthy achievers. Equally, approximately 22% each of respondents classified their socio-economic status as urban prosperity and moderate means, respectively. Nearly 45% of all respondents said the Abuja Environmental Protection Board, AEPB was responsible for collection and disposal of MSW generated from their residence. This response might be slightly misleading as evidence from literature shows that AEPB is no longer directly responsible for household waste collection and disposal (Akoni, 2007). The response might therefore be indicating a lack of understanding on the part of some respondents/residents of the operational details of waste management in the City.

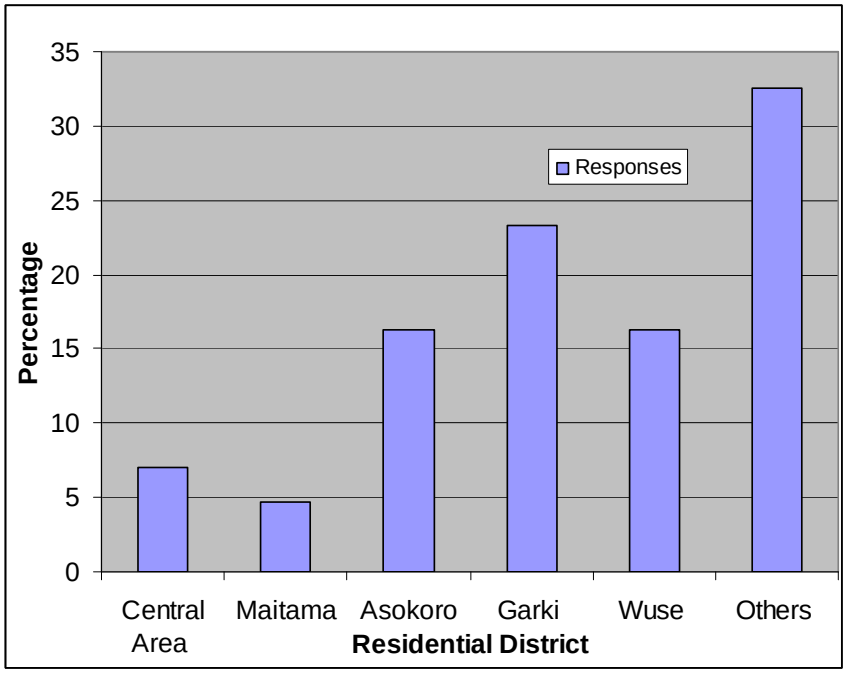

Figure 5.1: Distribution of respondents according to residential districts.

From Figure 5.3, approximately 25% of respondents said they disposed of their household waste themselves. As most of the designated dump sites and community disposal facilities are sometimes far from neighbourhoods, it is possible that this practise of direct disposal of waste by some residents may explain the cases of littering in the City, especially in the satellite towns. From Figure 5.4, nearly 35% of respondents said it was difficult to calculate the quantity of MSW generated from their homes as it fluctuates regularly. From the figure, about 15% said they generated more than a 240 L by volume of waste per week, while another 15% said they generated less than a standard bin (240 L) and less than a black bin bag, respectively, on a weekly basis.

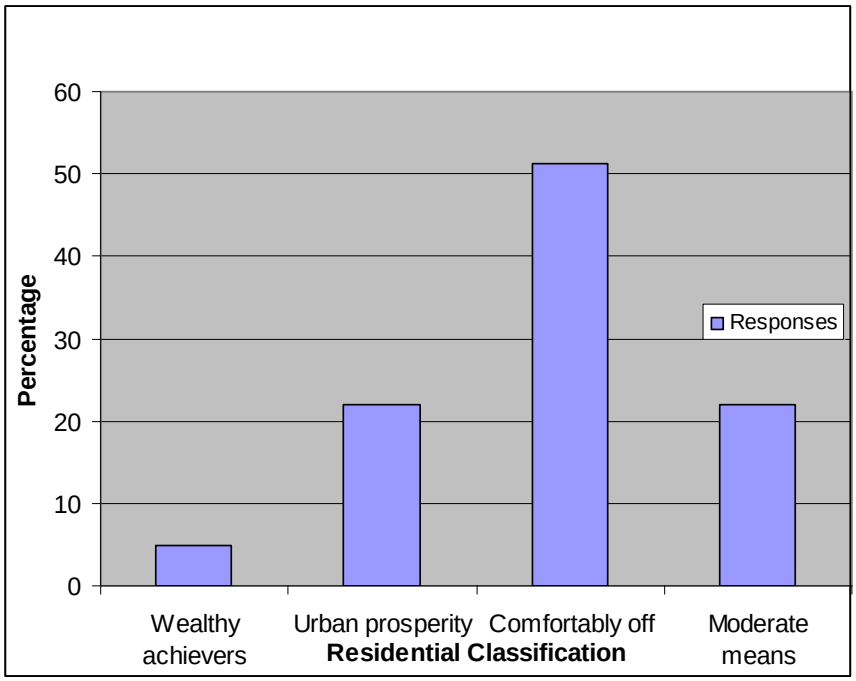

Figure 5.2: Distribution of respondents according to social classification.

Table 5.2 requested respondents to indicate how the listed barriers affect sustainable MSW management in the City using a sliding scale of 1 to 6. A value of 1 implies the factor is a minor barrier while 6 implies factor is a major barrier to waste management in the City. Most respondents cited low public awareness/education of MSW management, obsolete and insufficient equipment and funding limitations as the main barriers to sustainable management of MSW in Abuja. Other major barriers as identified by respondents were on the issue of training and remuneration of waste workers and strengthening of waste management institutions, policies and strategies.

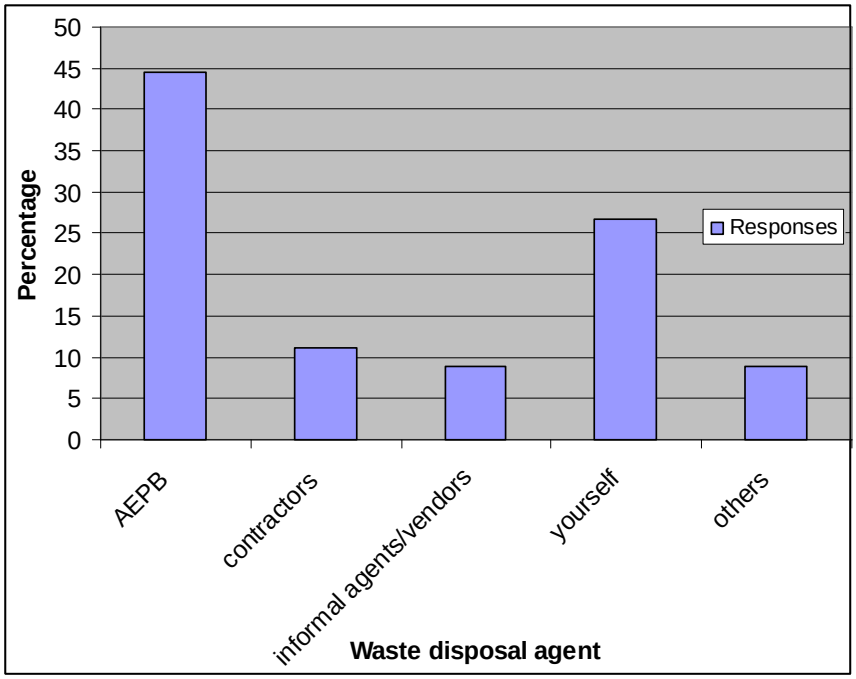

Figure 5.3: Waste collection/disposal agents identified by respondents.

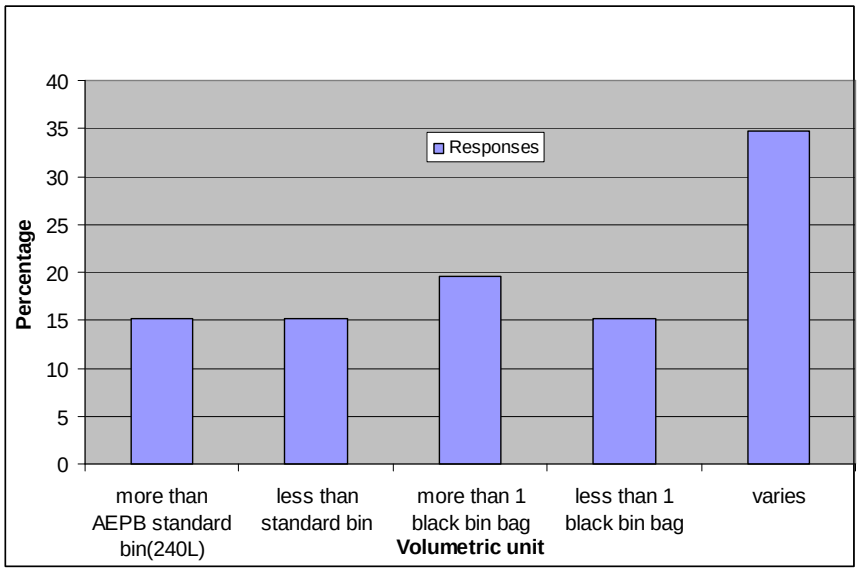

Figure 5.4: Estimation of weekly waste arising by respondents.

Table 5.2: Respondents' assessment of barriers affecting MSW management

	Please use the scale to indicate how the following barriers affect waste management in Abuja. A value of 1 will imply minor barrier while 6 implies factor is a major barrier to waste management in the City							Count	Percent
	1	2	3	4	5	6	not sure		
Waste policies lack clear strategies for action	3 (0.7%)	4 (0.94%)	9 (2.11%)	7 (1.64%)	7 (1.64%)	8 (1.88%)	5 (1.17%)	**43**	**10.09%**
Laws regulating waste management are inadequate	4 (0.94%)	6 (1.41%)	4 (0.94%)	10 (2.35%)	7 (1.64%)	8 (1.88%)	4 (0.94%)	**43**	**10.09%**
Waste management institutions are weak	4 (0.94%)	-	5 (1.17%)	10 (2.35%)	9 (2.11%)	11 (2.58%)	4 (0.94%)	**43**	**10.09%**
Unplanned aspects of the City make waste collection difficult	3 (0.7%)	7 (1.64%)	7 (1.64%)	8 (1.88%)	6 (1.41%)	8 (1.88%)	2 (0.47%)	**41**	**9.62%**
Density and high moisture content makes waste difficult to manage	4 (0.94%)	10 (2.35%)	11 (2.58%)	4 (0.94%)	8 (1.88%)	4 (0.94%)	2 (0.47%)	**43**	**10.09%**
Availability of dumping grounds discourages expensive investment in alternative disposal methods	8 (1.88%)	5 (1.17%)	9 (2.11%)	5 (1.17%)	5 (1.17%)	7 (1.64%)	3 (0.7%)	**42**	**9.86%**
Limited funds available are sometimes misused	3 (0.7%)	5 (1.17%)	3 (0.7%)	5 (1.17%)	8 (1.88%)	15 (3.52%)	4 (0.94%)	**43**	**10.09%**
Public education on waste management is low	3 (0.7%)	1 (0.23%)	5 (1.17%)	5 (1.17%)	11 (2.58%)	16 (3.76%)	2 (0.47%)	**43**	**10.09%**
Waste workers are poorly trained and poorly paid	4 (0.94%)	3 (0.7%)	5 (1.17%)	5 (1.17%)	12 (2.82%)	11 (2.58%)	2 (0.47%)	**42**	**9.86%**
Operational equipment are obsolete and insufficient	5 (1.17%)	2 (0.47%)	8 (1.88%)	3 (0.7%)	8 (1.88%)	15 (3.52%)	2 (0.47%)	**43**	**10.09%**
Count total	**41**	**43**	**66**	**62**	**81**	**103**	**30**	**426**	
Percent	**9.62%**	**10.09%**	**15.49%**	**14.55%**	**19.01%**	**24.18%**	**7.04%**		
Responses	43								

Respondents were asked to assess how the listed success factors in Table 5.3 affected waste management in Abuja using a sliding scale of 1 (minimal effect) and 6 (maximum effect). From the table the main success factor as identified by the majority of respondents is that the large City population is a potential market for recycled products, especially compost. Respondents were also of the opinion that a culture of informal sector recycling already exist in the City which could be mainstreamed into the overarching waste management strategy of the City to achieve greater efficiency.

Table 5.3: Respondents' assessment of success factors affecting MSW management

	Please use the scale to indicate how the following success factors will affect waste management in Abuja. A value of 1 will imply factor has minimal effect while 6 imply factor has major effect.							Count	Percent
	1	2	3	4	5	6	not sure		
A culture of informal sector recycling (scavenging) already exists in the City	5 (2.91%)	9 (5.23%)	13 (7.56%)	5 (2.91%)	2 (1.16%)	7 (4.07%)	3 (1.74%)	**44**	**25.58%**
Waste stream is highly compostable	-	8 (4.65%)	7 (4.07%)	11 (6.4%)	5 (2.91%)	5 (2.91%)	6 (3.49%)	**42**	**24.42%**
Large City population is a potential market for recycled products and compost	2 (1.16%)	4 (2.33%)	6 (3.49%)	10 (5.81%)	9 (5.23%)	9 (5.23%)	2 (1.16%)	**42**	**24.42%**
Recent emergence of small scale industries	3 (1.74%)	7 (4.07%)	12 (6.98%)	6 (3.49%)	9 (5.23%)	5 (2.91%)	2 (1.16%)	**44**	**25.58%**
Count total	**10**	**28**	**38**	**32**	**25**	**26**	**13**	**172**	
Percent	**5.81%**	**16.28%**	**22.09%**	**18.6%**	**14.53%**	**15.12%**	**7.56%**		
Responses	44								

5.2: Results from Main Questionnaire Survey: Chi Square Test

5.2.1: Respondents Distribution by Residential Districts

Table 5.4 represents the distribution of total respondents to the main questionnaire survey according to residential districts or location of business. From Table 5.4, Asokoro district had the least number of respondents at approximately 6.2% of total respondents. Maitama, Central Area and Garki districts had 8.6%, 9.4% and 19.5%, respectively. The district with the highest number of respondents in the survey was Wuse at 25.7%. Approximately 30% of the respondents came from satellite towns outside the municipal area, thus validating results from the pilot survey which also received a similar percentage of respondents. This is probably so because a large proportion of people who work in the Municipal area commute to work from many of the satellite towns around Abuja.

Table 5.4: Respondents distribution by residential districts

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Central area	144	9.2	9.4	9.4
	Maitama	132	8.5	8.6	18.0
	Asokoro	95	6.1	6.2	24.2
	Garki	300	19.3	19.5	43.7
	Wuse	395	25.4	25.7	69.4
	Others	470	30.2	30.6	100.0
	Total	1536	98.7	100.0	
Missing		21	1.3		
Total		**1557**	**100.0**		

Table 5.5 presents household size (number of occupants) distribution by residential districts. From the table, Wuse district has the highest proportion of one person households (22%). This might be indicative of greater proportion of low income earners in this district. Maitama and Central Area districts had the highest proportions of 11+ households at 52% and 51%, respectively. The two districts as well as Maitama are where most high income households reside. Culturally, such households support larger populations as a result of the extended family system which is still quite prevalent in Nigeria (Cox *et al.*, 2007; Morgan and Kannisto, 1973; Litwak, 1960).

A chi-square test was carried out to determine the degree of association between residential districts and household size. The result is shown as Table 5.6. The result shows a strong statistically significant relationship between the two variables, X^2 (20, N = 1519) = 4.565, p <0.05.

Table 5.5: Household size distribution by residential districts

Count							
		house hold size distribution (%)					
		1	2-4	5-7	8-10	11+	Total
residential district	Central Area	6	19	19	6	51	100
	Maitama	11	24	8	5	52	100
	Asokoro	2	37	43	8	9	100
	Garki	15	31	38	10	6	100
	Wuse	22	19	36	14	9	100
	Others	17	35	41	5	3	100

Table 5.6: Chi-square test results for relationship between household size and residential district

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.565E2	20	<0.001
Likelihood Ratio	397.084	20	<0.001
Linear-by-Linear Association	173.997	1	<0.001
N of Valid Cases	1519		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.26.			

5.2.2: Household Income Distribution

Figure 5.5 shows the distribution of household income by residential districts. From the figure, Garki and Wuse districts have the highest proportion of households earning less than 7500 Nigerian Naira monthly, at 14% and 9%, respectively. The Central Area and Maitama

on the other hand have the least numbers of low income households at 0% and 2%, respectively. The highest concentration of mid income (30,000-100,000 = N = per month) households are in Garki and the satellite towns. Maitama, Central Area and Asokoro have the highest concentration of high income households in the City.

A chi-square test was performed to determine the degree of association between residential districts and household income. The result is shown as Table 5.7. This result shows a strong statistically significant relationship between the two variables, X^2 (20, N=1475) = 4.12, p <0.05.

Table 5.7: Chi-square test results for relationship between household income and residential district

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.115E2	20	<0.001
Likelihood Ratio	346.604	20	<0.001
Linear-by-Linear Association	160.302	1	<0.001
N of Valid Cases	1475		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.41.

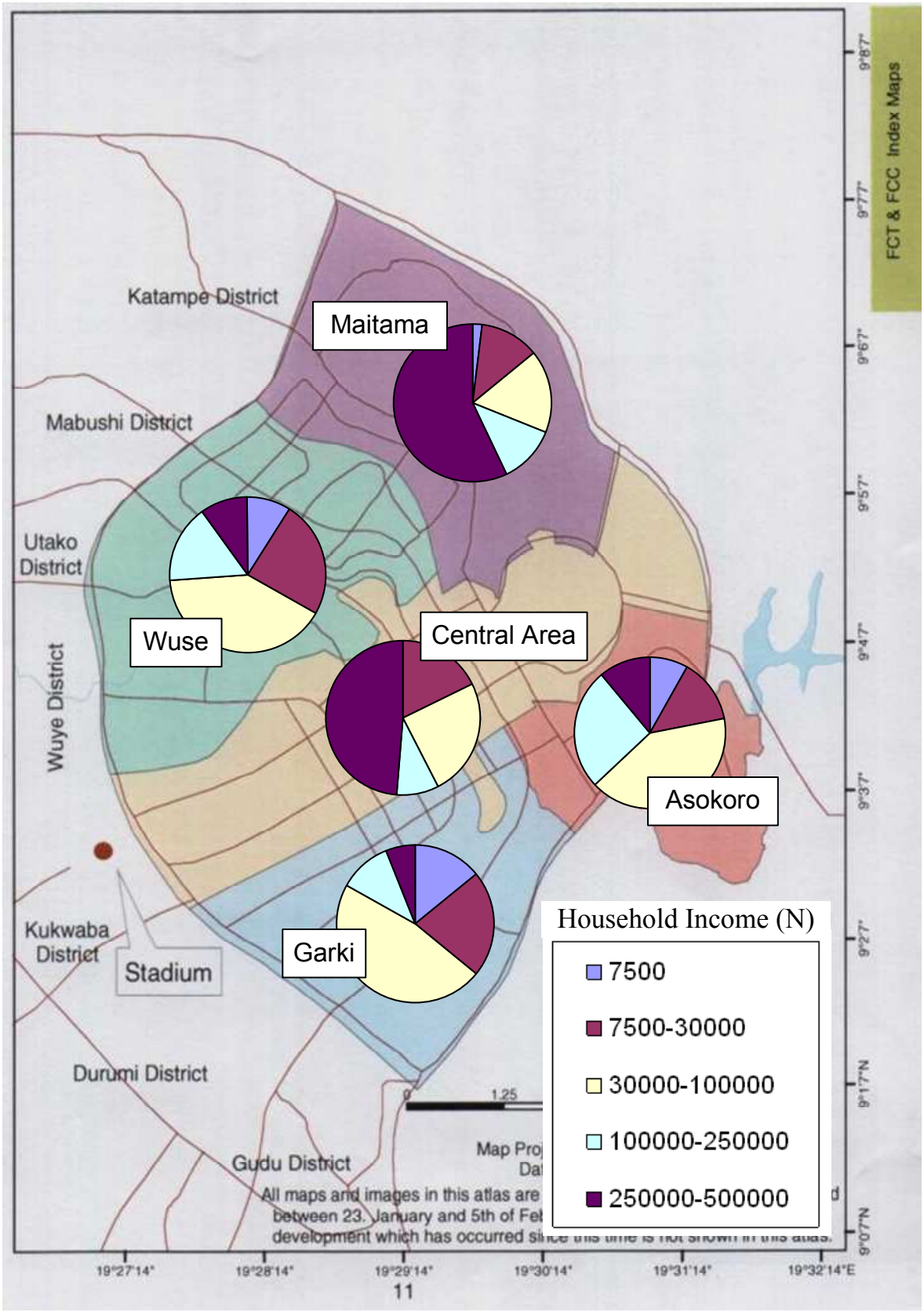

Figure 5.5: Household income by residential district [based on (Mohammed *et al.*, 1999)] Units are in Nigerian Naira (N).

5.2.3: Geodemographic classification of sampling area

Figure 5.6 represents a geodemographic map of the sampling area. From this map, Garki district has the highest concentration of hard pressed and moderate means (poor neighbourhoods) at 8% and 35%, respectively. This is in line with findings from Section 5.2.2. Garki and Wuse districts account for the largest concentrations of mid income neighbourhoods (the comfortably offs). However, Maitama and Asokoro could be described as largely consisting of neighbourhoods for wealthy achievers and prosperous urban dwellers. A chi-square test was performed to determine the degree of association between residential districts and geodemographic classification of neighbourhoods. The result is shown as Table 5.8. The result shows a strong statistically significant relationship between the two variables, X^2 (20, N=1131) = 33.80, p< 0.05.

Table 5.8: Chi-square test results for relationship between residential district and geodemographic classification

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	33.801[a]	20	0.028
Likelihood Ratio	32.014	20	0.043
Linear-by-Linear Association	6.461	1	0.011
N of Valid Cases	1131		

a. 4 cells (13.3%) have expected count less than 5. The minimum expected count is 3.05.

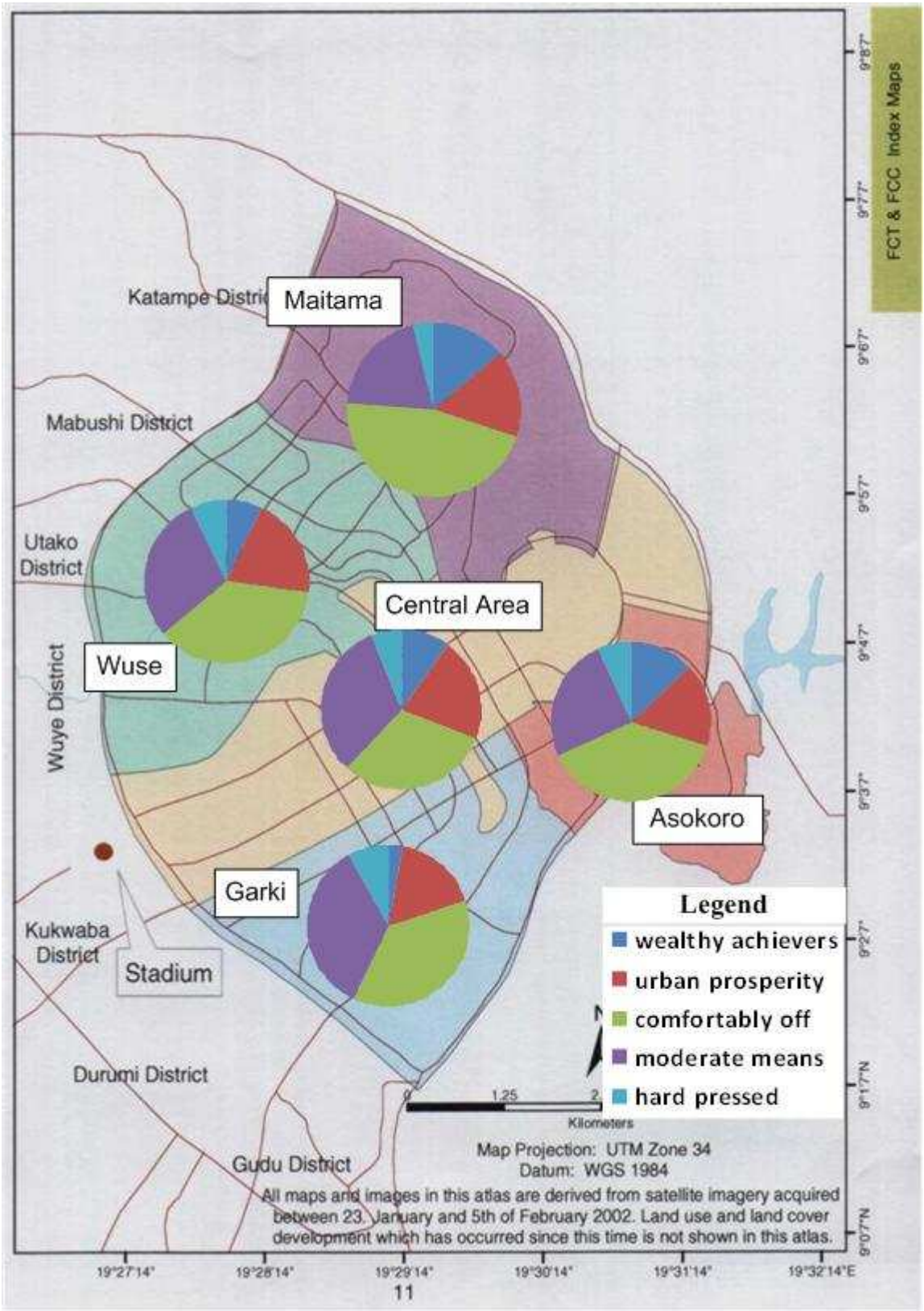

Figure 5.6: Geodemographic Classification of Abuja Districts [based on (Mohammed *et al.*, 1999)].

5.2.4: Assessment of Respondents Understanding of MSW Related Subjects

5.2.4.1: Assessment of Respondents' Knowledge of Waste Minimization

Table 5.9 presents results from a four-part question (A3) designed to assess the level of understanding of respondents of waste management subjects such as waste minimization, recycling, composting and the operations of the AEPB. From this table, out of the total 1557 responses gathered in the main survey, 1509 (96.9%) responses were received on this question. Total missing data was 48, equivalent to 3.1% of total responses. A scale of poor to excellent was used in measuring the level of knowledge of respondents in waste minimization. Approximately 47% of respondents said they had good to excellent knowledge of waste minimization. This result contrasts with the general perception and accounts in published literature that public awareness on MSW subjects in Abuja is rather low (Ezeah *et al.*, 2009b; Imam *et al.*, 2008; Adama, 2007). On the other hand 48% of respondents evaluated their knowledge of waste minimization to be between fair and very poor. If the number of respondents who were not sure of their response to the question were taken into consideration, the percentage of respondents with very low understanding of waste minimization knowledge went up even higher. This implies that over half of the survey population by self acclaim had very low understanding of waste minimization. It is possible that this number may be considerably higher given the tendency for respondents to project a more positive self image in self reported questionnaires (Tonglet *et al.*, 2004a; Chung, 2008).

Table 5.9: Assessment of respondents knowledge of waste minimization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not sure	102	6.6	6.8	6.8
	excellent	206	13.2	13.7	20.4
	very good	220	14.1	14.6	35.0
	good	276	17.7	18.3	53.3
	fair	200	12.8	13.3	66.5
	poor	153	9.8	10.1	76.7
	very poor	352	22.6	23.3	100.0
	Total	1509	96.9	100.0	
Missing		48	3.1		
Total		**1557**	**100.0**		

5.2.4.2: Assessment of Respondents' Knowledge of Recycling

Table 5.10 presents respondents level of understanding of recycling. From the table, of the total 1557 responses gathered in the main survey, 1500 (96.3%) responses were received on this question. Total missing data was 57, equivalent to 3.7% of total responses. Level of knowledge of recycling was measured from very poor to excellent. Approximately 37% of respondents said they had good to excellent knowledge of recycling. On the other hand about 52% of respondents evaluated their understanding of recycling to be between fair and very poor. About 11.3% of respondents were not sure of their response to the question. This might also indicate that respondents had little understanding of recycling. Overall, nearly 63% of survey population by self acclaim had little or no understanding of recycling.

Table 5.10: Assessment of respondents knowledge of recycling

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not sure	170	10.9	11.3	11.3
	excellent	196	12.6	13.1	24.4
	very good	150	9.6	10.0	34.4
	good	202	13.0	13.5	47.9
	fair	152	9.8	10.1	58.0
	poor	177	11.4	11.8	69.8
	very poor	453	29.1	30.2	100.0
	Total	1500	96.3	100.0	
Missing		57	3.7		
Total		**1557**	**100.0**		

5.2.4.3: Assessment of Respondents' Knowledge of Composting

Table 5.11 below presents data relating to respondents' level of understanding of composting. Of the total 1557 responses to the main survey, 1500 (96.3%) responses were received on this question. Total missing data was 66, equivalent to 4.2%. To measure respondent's understanding of composting, a scale of very poor to excellent was also used. Approximately 34% of respondents said they had good to excellent knowledge of

composting. On the other hand about 53% of respondents evaluated their understanding of composting to be between fair and very poor. About 13% of respondents were not sure of their response to the question. This might also indicate that respondent had little understanding of composting. Overall, nearly 66% of survey population by self acclaim had very low knowledge of composting.

Table 5.11: Assessment of respondents' knowledge of composting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not sure	196	12.6	13.1	13.1
	excellent	128	8.2	8.6	21.7
	very good	191	12.3	12.8	34.5
	good	190	12.2	12.7	47.3
	fair	166	10.7	11.1	58.4
	poor	233	15.0	15.6	74.0
	very poor	387	24.9	26.0	100.0
	Total	1491	95.8	100.0	
Missing		66	4.2		
Total		**1557**	**100.0**		

5.2.4.4: Assessment of respondents' knowledge of AEPB operations

Table 5.12 below presents data relating to the respondents level of understanding of the operations of Abuja Environmental Protection Board (AEPB). Of the total 1557 responses to the main survey, 1520 (97.6%) responses were received on this question. Total missing data was 35, equivalent to 2.2%. Approximately 53% of respondents said they had good to excellent knowledge of AEPB operations. On the other hand about 41% of respondents evaluated their understanding of AEPB operations to be between fair and very poor. About 6.1% of respondents were not sure of their response to the question. Overall, there appears to be a balance between the survey population with appreciable knowledge of AEPB operation and the ones with very little knowledge of AEPB operations.

Table 5.12: Assessment of respondents knowledge of AEPB operations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not sure	93	6.0	6.1	6.1
	excellent	261	16.8	17.2	23.3
	very good	258	16.6	17.0	40.3
	good	285	18.3	18.8	59.0
	fair	183	11.8	12.0	71.1
	poor	141	9.1	9.3	80.3
	very poor	299	19.2	19.7	100.0
	Total	1520	97.6	100.0	
Missing		35	2.2		
	Total	37	2.4		
Total		**1557**	**100.0**		

5.2.5: Assessment of Respondents' Performance in MSW Related Subjects

5.2.5.1: Assessment of Respondents' Performance in Environmental Sanitation

Table 5.13 presents results from a three part question A4 (1) in the questionnaire survey designed to assess respondents' actual performance on MSW related subjects such as environmental sanitation, recycling/reuse and composting. We deduce from Table 5.13 that out of the total 1557 responses gathered in the main survey, 1548 (99.4%) responses were received on this question. Total missing data were 9, equivalent to 0.6% of total responses. Approximately 69.7% of respondents rated their environmental sanitation performance between good to excellent. Conversely, about 25% of respondents evaluated their performance on environmental sanitation to be between fair and very poor. If the number of respondents who were not sure of their response to the question were taken into consideration, the percentage of respondents in this category increased to about 30%. The relatively high percentage of high performers in environmental sanitation corresponds to the general perception of Abuja as a very clean City by some respondents in the survey.

5.2.5.2: Assessment of Respondents' Performance in Recycling/Reuse

Table 5.14 presents results from the assessment of respondents' actual performance in recycling/reuse. We deduce from Table 5.14 that out of the total 1557 responses gathered in the survey, 1481 (95.1%) responses were received on this question.

Table 5.13: Assessment of respondents performance in environmental sanitation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not sure	78	5.0	5.0	5.0
	excellent	386	24.8	24.9	30.0
	very good	390	25.0	25.2	55.2
	good	304	19.5	19.6	74.8
	fair	136	8.7	8.8	83.6
	poor	122	7.8	7.9	91.5
	very poor	132	8.5	8.5	100.0
	Total	1548	99.4	100.0	
Missing		9	.6		
Total		**1557**	**100.0**		

Total missing data were 76, equivalent to 4.9% of total responses. Approximately 26% of respondents rated their recycling/reuse performance between good to excellent. On the other hand, nearly 60% of respondents evaluated their recycling/reuse performance to be between fair and very poor. If 14.9% respondents who were not sure of their response to the question were taken into consideration, the percentage of poor performers in recycling could be as high as 75% of respondents. Non-involvement of most residents in recycling and other pro-environmental activities could be traceable to the low levels of public education on sustainable management of MSW.

Table 5.15 represents a cross tabulation of the residential districts with estimates of recyclable household materials sent to the waste bin. From the table, the satellite towns, Wuse and Garki districts threw away the least percentage of their recyclable items in the bin. These districts coincide with the area which has the highest concentration of low income households. This finding supports the position of literature that poorer neighbourhoods tend generally to generate less waste (Daskalopoulos *et al.*, 1998; Otoniel *et al.*, 2008). Central

Area and Maitama districts were found to recycle the least of their household waste when compared with other areas.

Table 5.14: Assessment of respondents' performance in recycling

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not sure	220	14.1	14.9	14.9
	excellent	104	6.7	7.0	21.9
	very good	142	9.1	9.6	31.5
	good	140	9.0	9.5	40.9
	fair	177	11.4	12.0	52.9
	poor	217	13.9	14.7	67.5
	very poor	481	30.9	32.5	100.0
	Total	1481	95.1	100.0	
Missing		76	4.9		
Total		**1557**	**100.0**		

A chi-square test was carried out to determine the degree of association between residential districts and recyclable items binned in the districts. The result is shown as Table 5.16. This result shows a strong, statistically significant, relationship between the two variables, X^2 (20, N= 1500) = 84.13, p<0.05.

Table 5.15: Residential district cross tabulation with estimates of recyclable items sent to bins

Count

		estimate recyclable items binned				
		5%	19.5%	39.5%	50%	Total
residential district	Central Area	31	30	24	14	100
	Maitama	34	39	17	8	100
	Asokoro	39	31	26	4	100
	Garki	45	33	15	7	100
	Wuse	51	29	12	7	100
	Others	53	30	12	5	100

Table 5.16: Chi-square test results for relationship between recyclable items sent to bins and residential district

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	84.128[a]	20	<0.001
Likelihood Ratio	74.040	20	<0.001
Linear-by-Linear Association	45.885	1	<0.001
N of Valid Cases	1500		

a. 6 cells (20.0%) have expected count less than 5. The minimum expected count is 0.44.

5.2.5.3: Assessment of Respondents' Performance in Composting

Table 5.17 presents results from a three part question A4 (2) in the questionnaire survey designed to assess respondents' actual performance in composting. It can be deduce from table 5.17 that of the total 1557 responses gathered in the main survey, 1474 (94.7%) responses were received on this question. Total number of missing data was 83 equivalent to 5.3% of total responses. Approximately 28% of respondents rated their composting performance between good to excellent. On the other hand, nearly 55% of respondents evaluated their composting performance to be between fair and very poor. If the 17.3% of respondents who were not sure of their response to the question were taken into consideration, the percentage of poor performers in composting could be as high as 72% of all respondents. These figures are quite similar to results from the evaluation of recycling/reuse performance, underlining the fact that both practises at the top end of the waste hierarchy model of best practises have not yet been imbibed by most Abuja residents.

5.2.6: Analysis of Waste Generation and Collection

5.2.6.1: Estimation of Weekly MSW Generation

Table 5.18 presents results of the evaluation of operational aspects of MSW generation and collection. From this table, it can be deduce that of the total 1557 responses gathered in the main survey, 1536 (98.7%) responses were received on this question, designed to ascertain the average weekly volume of waste arising from individual households. The total number of missing data were 21, equivalent to 1.3% of total responses.

Table 5.17: Assessment of respondents' performance in composting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not sure	255	16.4	17.3	17.3
	excellent	95	6.1	6.4	23.7
	very good	183	11.8	12.4	36.2
	good	139	8.9	9.4	45.6
	fair	156	10.0	10.6	56.2
	poor	214	13.7	14.5	70.7
	very poor	432	27.7	29.3	100.0
	Total	1474	94.7	100.0	
Missing		83	5.3		
Total		**1557**	**100.0**		

Weekly volume of MSW generation per household are outlined as follows: (1) 21.2% of respondents generated more than 240 L by volume of MSW per week (2) 26.8% of respondents said they generated less than 240 L by volume of MSW per week (3) 16.1% of respondents said they generated more than a black bin bag of MSW per week from their household (4) 9.2% of respondents said they generated less than a black bin bag of MSW per week, while another 26.7% of respondents said the volume of MSW they generated weekly varied widely.

Table 5.18: Estimated weekly MSW generation per household

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	more than 240 L	325	20.9	21.2	21.2
	less than 240 L	412	26.5	26.8	48.0
	more than bin bag	248	15.9	16.1	64.1
	less than bin bag	141	9.1	9.2	73.3
	varies	410	26.3	26.7	100.0
	Total	1536	98.7	100.0	
Missing		21	1.3		
Total		**1557**	**100.0**		

Table 5.19 represents a cross tabulation of residential districts with the type of container used by household for waste collection. From the table, the more affluent neighbourhoods of Central Area, Maitama and Asokoro use mostly the recommended 240 L standard bins for waste collection. For instance 56% of residents of Central Area district use 240 L plastic receptacles for waste collection as compared to Garki district at 39%. Only 3% of Maitama residents use open containers for waste collection. Open containers are mostly used by households in the satellite towns (14%), and poorer neighbourhoods of Garki (8%) and Wuse (8%). Apart from open containers, these districts also utilize mostly communal facilities for waste collection.

A chi-square test was performed to determine the degree of association between residential districts and type of container used for waste collection. The result is shown as Table 5.20. The result shows a strong statistically significant relationship between the two variables, X^2 (20, N=1515) = 1.33, p< 0.05.

Table 5.19: Residential district cross tabulation with type of container used for waste collection

residential district * waste container type Cross tabulation

Count

		waste container type					
		240 L bins	other covered bins	black bin bags	communal bins	open container	Total
residential district	Central area	56	18	7	15	4	100
	Maitama	41	21	17	17	3	100
	Asokoro	53	22	17	4	4	100
	Garki	39	21	23	8	8	100
	Wuse	49	21	15	8	8	100
	Others	23	29	25	9	14	100

Table 5.20: Chi-square test results for relationship between type of waste container and residential district

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.337E2	20	<0.001
Likelihood Ratio	139.806	20	<0.001
Linear-by-Linear Association	32.608	1	<0.001
N of Valid Cases	1515		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.35.

Table 5.21 represents a cross tabulation of residential districts with estimated weekly volume of waste arising. From the table, 28% of Asokoro residents reported weekly waste generation rates of over 240 L. The district equally reported the highest rates of household weekly waste arising of less than 1 bin bag (15%). However, Wuse district, a not so affluent district, at the same time reported nearly as many cases of over 240 L weekly waste generation per household (26%) with weekly waste arising of less than a black bin bag reported by (11%) of households in Wuse during the same period. This might imply that variations in volume of waste arising occurred both within and between the districts (Roberts *et al.*, 2009).

A chi-square test was performed to determine the degree of association between residential districts and weekly volume of waste arising. The result is shown as Table 5.22. This result shows a strong statistically significant relationship between the two variables, X^2 (20, N = 1517) = 1.05, p <0.05.

Table 5.23 represents a cross tabulation of household income with estimated weekly volume of waste arising. From the table, 44% of households earning between 250, 000-500,000 Naira per month reported weekly waste generation volumes of over 240 L. On the other hand only 35% of household earning between 250,000-500,000 Naira per month reported weekly waste generation rates of over 240 L by volume. Some 33% of households earning less than 7,500 Naira monthly generated less than a bin bag of waste weekly. This might indicate that while there is a positive relationship between household income and waste arising, the relationship may not necessarily be linear in all cases (Troschinetz and Mihelcic, 2009; Parrot *et al.*, 2009).

Table 5.21: Residential district cross tabulation with estimate of weekly volume of waste arising

residential district * wkl vol of MSW estimate Cross tabulation

Count

		wkl vol of MSW estimate					
		more than 240 L	less than 240 L	more than bin bag	less than bin bag	varies	Total
residential district	Central area	20	24	5	7	43	100
	Maitama	15	23	10	5	46	100
	Asokoro	28	37	14	15	6	100
	Garki	20	29	21	6	24	100
	Wuse	26	27	15	11	21	100
	Others	17	24	20	11	27	100

Table 5.22: Chi-square test results for relationship between estimates of weekly volume of waste arising and residential district

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.053E2	20	<0.001
Likelihood Ratio	110.239	20	<0.001
Linear-by-Linear Association	4.223	1	0.040
N of Valid Cases	1517		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.64.

A chi-square test was performed to determine the degree of association between household income and weekly volume of waste arising. The result is shown as Table 5.24. This result indicates a strong statistically significant relationship between the two variables, X^2 (16, N = 1477) = 4.07, p <0.05.

Table 5.23: Household incomes cross tabulation with estimate of weekly volume of waste arising

Crosstab

Count

		wkl vol of MSW estimate					
		more than 240 L	less than 240 L	more than bin bag	less than bin bag	varies	Total
income range (=N=)	7500	10	16	13	33	27	100
	7500-30000	12	24	14	16	33	100
	30000-100000	14	36	25	6	19	100
	100000-250000	44	34	11	1	10	100
	250000-500000	35	9	6	3	47	100

Table 5.24: Chi-square test results for relationship between estimates of weekly volume of waste arising and household income

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.072E2	16	<0.001
Likelihood Ratio	387.982	16	<0.001
Linear-by-Linear Association	33.688	1	<0.001
N of Valid Cases	1477		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.67.

5.2.6.2: Outline of MSW Collection Agents in Abuja

Table 5.25 represents results from Section B1 (waste generation and collection) of the household questionnaire survey outlining the main MSW collection agents in the City of Abuja. From this table it can be deduced that out of the total 1557 responses gathered in the main survey, 1534 (98.5%) responses were received on this question. The total number of missing data was 23, an equivalent of 1.5% of total responses. From Table 5.25, five principal waste collection agents are identified: AEPB, private waste contractors, self, informal agents/scavengers and others. This result indicates that about 33.3% of total MSW arising in the City is collected directly by AEPB, the statutory waste collection authority in

the City. These are mainly collected from government and institutional bodies, businesses and sometimes households, especially in instances where engaged private waste contractors are unable to discharge their duties appropriately. Approximately 41% of MSW arising from the City are collected by waste contractors who have jurisdiction over waste collection zones in the City, working in a public private partnership with the AEPB. These are mostly waste from households and certain commercial premises. In instances where these contractors are unable to carry out their duties appropriately as a result of operational difficulties, the AEPB steps in and the cost of doing so is back charged to the accounts of the private collectors. Other waste collection agencies in the City include scavengers that are often engaged by individuals for waste collection and disposal on ad-hoc basis. Waste collected by scavengers account for about 9.9% of total waste arising from the City. In certain instances also members of the family especially young persons directly collect and dispose their waste for no charge. This form of collection accounts for about 12.2% of total MSW arising in the City.

Table 5.25: Outline of MSW collection agents in Abuja

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	AEPB	511	32.8	33.3	33.3
	contractor	642	41.2	41.9	75.2
	informal agents	152	9.8	9.9	85.1
	yourself	195	12.5	12.7	97.8
	others	34	2.2	2.2	100.0
	Total	1534	98.5	100.0	
Missing		23	1.5		
Total		**1557**	**100.0**		

5.2.6.3: Outline of Average Monthly Expense on MSW Services per Household

Table 5.26 presents results from Section B1 (waste generation and collection) of the household questionnaire survey outlining average monthly cost of accessing MSW management services provided either directly by the AEPB or through their contractors. From this table it can be deduced that out of the 1557 responses gathered in the survey, 1510 (97%) responses were received on this question. The total number of missing data was 47, an equivalent of 3% of total responses. Table 5.26 categorizes household monthly MSW

expenditure into five main groups: under 500 Naira, 500-1000 Naira, 1000-5000 Naira, over 5000 Naira and variable charges. From this table, about 35.7% of residents of Abuja pay less than 500 Naira per month for the MSW management services they receive. At current exchange rates of about 250 Naira to the GB Pound, this would imply that more than a third of Abuja residents pay less than £2 per month for waste collection and disposal services. About 26% of respondents paid between 500-1000 Naira, while 15.6% of all respondents said they paid between 1000-5000 Naira. 6.8% of respondents paid over 5000 Naira monthly for MSW management services while about 16% said the amount they pay for waste management services varies.

From earlier results, more than 12% of households, especially those living in the satellite towns do not pay for waste services as they mostly disposed of their waste themselves. Residents of the wealthier areas of the City, such as Asokoro and Maitama tend to pay more for their waste services; such areas are usually managed directly by the AEPB.

Table 5.26: Outline of average monthly expense on MSW services per household

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid					
	500	539	34.6	35.7	35.8
	500-1000	392	25.2	26.0	61.7
	1000-5000	235	15.1	15.6	77.3
	5000	102	6.6	6.8	84.0
	varies	241	15.5	16.0	100.0
	Total	1510	97.0	100.0	
Missing		47	3.0		
Total		**1557**	**100.0**		

Table 5.27 represents a cross tabulation of residential district with average monthly expenses on waste services. From the table, it can be seen that between 14% and 38% of respondents pay under 500 Naira per month for waste services (equivalent to £2/month). Asokoro and Maitama residents tend to pay more for waste services 19% and 14%, respectively. About 42% of respondents from Maitama districts said the amount they pay for waste services

varied. On the whole, there appears to be no consistency across the districts in the amount charged for waste services by AEPB.

A chi-square test was performed to determine the degree of association between average monthly expenses for waste services and residential districts. The result is shown as Table 5.28. The result shows a strong statistically significant relationship between the two variables, X^2 (25, N = 1491) = 2.27, p <0.05.

Table 5.27: Residential district cross tabulation with average monthly expenses on waste services.

residential district * average monthly expense on waste Cross tabulation

Count

		average monthly expense on waste					
		500	500-1000	1000-5000	5000	varies	Total
residential district	Central area	33	12	19	9	27	100
	Maitama	14	23	7	14	42	100
	Asokoro	33	31	13	19	3	100
	Garki	44	35	11	4	6	100
	Wuse	34	24	23	8	11	100
	Others	38	26	15	3	19	100
	Total	196	151	87	57	108	

Table 5.28: Chi-square test results for relationship between average monthly expenses for waste services and residential districts

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.271E2	25	<0.001
Likelihood Ratio	214.404	25	<0.001
Linear-by-Linear Association	25.566	1	<0.001
N of Valid Cases	1491		

a. 6 cells (16.7%) have expected count less than 5. The minimum expected count is 0.06.

Table 5.29 represents a cross tabulation of household income with average monthly expenses on waste services. From the table, it can be seen that 73% of those earning under 7,500 Naira monthly pay about 500 Naira per month for waste services i.e. about 7% of net monthly

income. On the other hand, 0ver 50% of middle income earners (30,000-100,000 Naira/month) pay between 500-1000 Naira for waste services i.e. about 1% of net monthly income. This might be implying that in absolute terms, wealthier residents tended to pay less for waste services in the City. This situation impacts rather negatively on the financial position of the AEPB as they have had to rely consistently on government subvention for their operations over the years. This finding indicates possibilities for restructuring of AEPB's billing system to make it more sustainable.

A chi-square test was performed to determine the degree of association between household income and average monthly expenses on waste services. The result is shown as Table 5.30. The result shows a strong statistically significant relationship between the two variables, X^2 (20, N = 1457) = 1.28, p <0.05.

Table 5.29: Household incomes cross tabulation with average monthly expenses on waste services

Crosstab

Count		average monthly expense on waste					
		500	500-1000	1000-5000	5000	varies	Total
income range (=N=)	7500	73	8	0	0	19	100
	7500-30000	66	11	5	0	19	100
	30000-100000	32	53	7	0	8	100
	100000-250000	3	12	62	14	8	100
	250000-500000	10	2	19	36	34	100
	Total	184	86	93	50	87	

Table 5.30: Chi-square test results for relationship between average monthly expenses for waste services and household income

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.281E3	20	<0.001
Likelihood Ratio	1173.115	20	<0.001
Linear-by-Linear Association	278.510	1	<0.001
N of Valid Cases	1457		

a. 5 cells (16.7%) have expected count less than 5. The minimum expected count is 0.09.

5.2.6.4: Estimation of Food Waste Component in the Waste Stream

Table 5.31 presents results from Section B2 (recycling, composting and waste transfer) of the questionnaire survey. From this table we deduce that out of the total 1557 responses gathered in the survey, 1169 (75.1%) responses were received on this question. The total number of missing data was 388, an equivalent of 24.9% of total responses. It is not quite clear why the percentage of missing numbers was so high, but it is possible some respondents found it difficult to assign numerical values to the amount of food waste from their homes. From Table 5.31, about 78% of respondents said they disposed under 5% of their cooked food and food products regularly. 14.7% of respondents said they disposed of about 20% of their food in the waste bin, while just about 4% and 3% of respondents said they disposed of as much as 40% and 50% respectively of their food and food products in the waste bins. These findings reflect the position of literature that there is minimal wastage of food and food products amongst the lower income bracket of urban dwellers in SSA countries (von Braun and Paulino, 1990). These results also agree with findings from literature that as household income increases, waste tends to increase linearly (Refsgaard and Magnussen, 2009; Read *et al.*, 2009), hence we find that about 3% of respondents said they waste as much as 50% of their food and food products.

Table 5.31: Estimated food waste component in the MSW stream in Abuja

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5%	909	58.4	77.8	77.8
	19.5%	172	11.0	14.7	92.5
	39.5%	47	3.0	4.0	96.5
	50%	34	2.2	2.9	100.0
	Total	1169	75.1	100.0	
Missing		388	24.9		
Total		**1557**	**100.0**		

Table 5.32 represents a cross tabulation of residential districts with percentage of food waste. From the table, it can be seen that 82% of Garki residents waste less than 5% of their food and food purchases regularly. This figure compares with 79% and 77% recorded in Maitama and Wuse districts, respectively. Equally, the table shows that about 4% of Asokoro residents waste as much as 50% of their cooked food.

A chi-square test was performed to determine the degree of association between residential districts and percentage of food waste disposed in the waste stream. The result is shown as Table 5.33. The result shows a strong statistically significant relationship between the two variables, X^2 (20, N = 1161) = 43.08, p <0.05.

Table 5.32: Percentage of food waste by residential districts

Crosstab

Count		percentage cooked food binned				
		5%	19.5%	39.5%	50%	Total
residential district	Central area	71	26	0	3	100
	Maitama	79	17	4	0	100
	Asokoro	68	20	8	4	100
	Garki	82	11	5	2	100
	Wuse	77	13	7	2	100
	Others	78	15	1	4	100

Table 5.33: Chi-square test results for relationship between residential districts and percentage of food waste

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	43.076[a]	20	0.002
Likelihood Ratio	49.442	20	<0.001
Linear-by-Linear Association	.009	1	0.926
N of Valid Cases	1161		

a. 12 cells (40.0%) have expected count less than 5. The minimum expected count is 0.29.

5.2.6.5: Respondents' Assessment of AEPB's MSW Services

Table 5.34 presents results from Section C1 (waste policy and strategy) of the household questionnaire survey designed to rate respondents' level of satisfaction of MSW management services provided by the AEPB. From this table we deduce that out of the total 1557 responses gathered in the main survey, 1519 (97.6%) responses were received. The total number of missing data was 38, an equivalent of 2.4% of total responses. From Table 5.34, 8.6%, 21.5% and 24.4% of respondents indexed AEPB's MSW services as very satisfactory, good and satisfactory, respectively. This implies that about 55% of respondents were quite satisfied with MSW management services provided by the AEPB. On the other hand 28% of respondents rated these services as fair while 8.1% and 6.8% of respondents rated them as poor and very poor, respectively. 2.5% of respondents were unable to rate the services at all.

On the whole while 55% of the respondents rated the services as good, approximately 45% of respondents rated the services poorly. This tends to indicate a near equal divide amongst respondents connoting that there still exists ample room for improvement in services delivered by the AEPB.

Table 5.34: AEPB services satisfaction index

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not sure	38	2.4	2.5	2.5
	very satisfactory	131	8.4	8.6	11.1
	good	327	21.0	21.5	32.7
	satisfactory	370	23.8	24.4	57.0
	fair	426	27.4	28.0	85.1
	poor	123	7.9	8.1	93.2
	very poor	104	6.7	6.8	100.0
	Total	1519	97.6	100.0	
Missing		38	2.4		
Total		1557	100.0		

Table 5.35 represents a cross tabulation of residential districts with AEPB satisfaction index. From the table, more respondents, irrespective of area of residence rated AEPB services between fair and good than between fair and poor. For instance 31% of respondents from Central area said AEPB services were good as compared with 22% in Maitama and 31% in Asokoro. On the other hand 27% of respondents in Central area said AEPB services were fair as compared with 20% in Maitama and 26% in Asokoro who hold the same view. Only respondents from Garki (10%), Wuse (4%) and other satellite towns (13%) believe that AEPB services were poor. The high percentage of respondents from satellite towns holding this view may be as a result of low coverage of AEPB services in such areas.

A chi-square test was performed to determine the degree of association between residential districts and AEPB satisfaction index. The result is shown as Table 5.36. The result shows a strong statistically significant relationship between the two variables, X^2 (30, N = 1500) = 1.51, $p<0.05$.

Table 5.35: Residential district cross tabulation with AEPB satisfaction index

residential district * sat index of AEPB services Cross tabulation

Count

		sat index of AEPB services							
		not sure	very satisfactory	good	satisfactory	fair	poor	very poor	Total
residential district	Central area	1	7	31	27	27	7	0	100
	Maitama	0	8	22	47	20	3	0	100
	Asokoro	0	12	31	24	26	7	0	100
	Garki	3	7	20	23	28	9	10	100
	Wuse	2	13	22	24	30	6	4	100
	Others	5	6	17	19	28	12	13	100

Table 5.36: Chi-square test results for relationship between residential districts and AEPB satisfaction index

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.508E2	30	<0.001
Likelihood Ratio	169.462	30	<0.001
Linear-by-Linear Association	20.595	1	<0.001
N of Valid Cases	1500		

a. 3 cells (7.1%) have expected count less than 5. The minimum expected count is 2.31.

5.2.6.6: Outline of MSW disposal agents in Abuja

Table 5.37 represents results outlining the main MSW disposal agents in the City of Abuja (see question 28, Section D of research questionnaire). From this table we deduce that out of the total 1557 responses gathered in the survey, 1530 (98.3%) responses were received on this question. The total number of missing data was 27, an equivalent of 1.7% of total responses. From Table 5.37, five principal waste disposal agents were identified: AEPB, private waste contractors, informal agents/scavengers and self disposal. The table shows that 43.1% of total MSW arising in the City is disposed directly by AEPB. This figure shows a

10% differential between reported collection and disposal figures by AEPB. This is explained by the fact that AEPB sometimes directly disposes waste collected by their sub contractors. Approximately 29% of MSW arising from the City are disposed off by waste contractors who have jurisdiction over particular waste management zones in the City. About 7% of MSW generated from the City is disposed off by informal agents/scavengers. Table 5.37 also shows that householders directly dispose off about 21% of total MSW arising from the City. This implies that nearly a third of the total solid waste arising from the City do not find their way into the formal waste management route designed by the AEPB. This practise may account for the high level of littering recorded in various parts of the City especially around the satellite towns. As earlier indicated in Chapter Two, even the AEPB and their sub contractors ultimately dispose off the waste they collect at open dumpsites such as the Gosa dump site as there are no sanitary land fills in the City presently.

Table 5.37: Outline of MSW disposal agents in Abuja

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	AEPB	660	42.4	43.1	43.1
	private contractors	443	28.5	29.0	72.1
	scavengers	105	6.7	6.9	79.0
	yourself	322	20.7	21.0	100.0
	Total	1530	98.3	100.0	
Missing		27	1.7		
Total		**1557**	**100.0**		

5.2.6.7: MSW Disposal Methods in Abuja

Table 5.38 represents results outlining the commonest MSW disposal methods in the City. This table shows that of the 1557 responses gathered in the survey, 1514 (97.2%) responses were received on this question. The total number of missing data was 43, an equivalent of 2.8% of total responses. From Table 5.38, four principal MSW disposal methods were identified: sanitary landfills, open dumping, burning and incineration. The table shows that 15.7% of respondents said their waste was disposed of at sanitary landfills. As has been reiterated in the preceding sections, no engineered or sanitary landfill exists yet in the City. It is therefore possible that the misconception is as a result of inadequate understanding of the

essential differences between sanitary landfills and ordinary dumpsites on the part of some respondents. From the table we also deduce that 63.1% of respondents said their waste was disposed of at dumpsites, while another 14.5% said their waste was disposed of by open burning. About 6.7% of respondents reported that their waste was disposed of by incineration. This response might be out of a misconception as interviews with AEPB authorities' show there are no incinerators currently in the City. It may therefore be concluded that nearly all MSW arising in the City is disposed off at the City's central dump site in Gosa or separately by individuals at isolated illegal dumpsites that litter the City landscape.

Table 5.38: Outline of MSW disposal methods in Abuja

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	sanitary landfills	238	15.3	15.7	15.7
	open dumping	956	61.4	63.1	78.9
	burning	219	14.1	14.5	93.3
	incinerators	101	6.5	6.7	100.0
	Total	1514	97.2	100.0	
Missing		43	2.8		
Total		**1557**	**100.0**		

5.2.6.8: Factors Responsible for Open Dumping of MSW in Abuja

Table 5.39 presents results outlining the factors responsible for open dumping of MSW in Abuja. From this table we deduce that out of the total 1557 responses gathered in the main survey, 1527 (98.1%) responses were received on this question. The total number of missing data was 30, an equivalent of 1.9% of total responses. From Table 5.39, four reasons were identified as being responsible for open dumping in Abuja: (1) waste management facilities are unavailable or inadequate, (2) adequate information on sustainable disposal options are not available to residents, (3) legal deterrents by way of penalties are not enforced and (4) offenders are motivated to save costs. From the table, 41.5% of respondents identified absence of MSW management facilities as the key factor responsible for open dumping. 19.6% of respondents, however, are of the view that the key reason responsible for open waste dumping in the City is the absence of timely information on alternative (sustainable)

disposal options. On the other hand, about 31% of respondents believe that the AEPB does not have the will to enforce the penalties for open dumping as stipulated by law to serve as deterrent for fly tipping. The absence of such stiff penalties is thought to be an incentive for open dumping. Apart from the already mentioned factors, about 8.3% of respondents believe that the tendency to maximize profits by saving cost is a key factor driving open dumping of MSW in the City, especially by businesses and large organizations.

Table 5.39: Factors responsible for open dumping of MSW in Abuja

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no facilities were provided	633	40.7	41.5	41.5
	inadequate information	300	19.3	19.6	61.1
	no penalty for defaulters	467	30.0	30.6	91.7
	to save cost	127	8.2	8.3	100.0
	Total	1527	98.1	100.0	
Missing		30	1.9		
Total		**1557**	**100.0**		

5.2.6.9: Residential District Cross Tabulation with Respondents Groups

Table 5.40 represents a cross tabulation of residential districts with respondents' groups. The table gives a breakdown summary of all respondents groups according to district of domicile. The table shows that most respondents in the policy group live in either Central area (44%) or Maitama (47%). This is understandable as historically these two districts together with Asokoro have been the selective preserve of the upper income segment of the population. On the other hand most businesses are located in Wuse districts (43%), satellite towns (35%) and Garki (16%). The survey captured no business presence in Asokoro district. The third group of respondents, households, however have a more even spread in all districts of the City: satellite towns (33%), Wuse (26%), Garki (23%), Asokoro (8%), Central area (6%) and Maitama (5%).

A chi-square test was carried out to determine the degree of association between residential districts and respondent groups. The result is shown as Table 5.41. This result shows a strong statistically significant relationship between the residential districts and respondent groups, X^2 (10, N = 1536) = 6.58, p <0.05.

Table 5.40: Residential district cross tabulation with respondents groups

Crosstab

Count

		residential district						
		central area	Maitama	Asokoro	Garki	Wuse	others	Total
type of respondent	households	6	5	8	23	26	33	100
	businesses	3	3	0	16	43	35	100
	policymakers	44	47	2	0	2	5	100

Table 5.41: Chi-square test results for relationship between residential districts and respondents groups

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.584E2	10	<0.001
Likelihood Ratio	522.480	10	<0.001
Linear-by-Linear Association	249.036	1	<0.001
N of Valid Cases	1536		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.46.

Table 5.42 represents a cross tabulation of respondent groups with AEPB satisfaction index. The table gives a breakdown of the Table 5.34 in Section 5.2.6.5 according the respondent groups in the survey. In a scale that ranged from very satisfactory to poor, 54% of households in the survey indexed AEPB services between satisfactory and very satisfactory, while about 43% rated AEPB services between fair and very poor. Conversely 45% of businesses indexed the services between satisfactory and very satisfactory while approximately 54% rated the services between fair and very poor. The policy makers sub-group appears to be the most satisfied of all three groups with regard to AEPB's services as about 79% of policy makers indexed AEPB's services from satisfactory to very satisfactory. On the other hand just about 22% of policy makers indexed AEPB services as fair to very poor.

Table 5.42: AEPB satisfaction index cross tabulation with respondents groups

Crosstab

Count

		sat index of AEPB services							
		not sure	very satisfactory	good	satisfactory	fair	poor	very poor	Total
type of respondent	households	3	10	21	23	27	9	7	100
	businesses	2	4	20	21	38	7	9	100
	policymakers	0	7	31	41	22	0	0	100

5.3: Analysis of Variance (ANOVA)

5.3.1: General Linear Model

Statistically, the general linear model (GLM) is represented by the linear model

Y = XB+U

Where **Y** is a matrix with series of multivariate measurements, **X** is a design matrix, **B** is a matrix containing parameters that are usually to be estimated and **U** is a matrix containing errors. The general linear model incorporates a number of different statistical models such as ANOVA, ordinary regression, F-test and t-test. Where there is only one column in **Y** (i.e., one dependent variable) then the model can also be referred to as the multiple regression model (Mardia *et al.*, 1979). Hypothesis testing using general linear model can be made in two ways: multivariate and mass-univariate. Most of the data generated from the questionnaire survey were ordinal in nature (responses were mainly ratings measured on the Likert scale). This group of data were initially subjected to a test for normality which showed that data were approximately normally distributed. Following Tonglet *et al.*(2004a), analysis of such rating data was carried out using Analysis of Variance (ANOVA).

5.3.2: Analysis of Responses to Question A3: Measuring Knowledge of MSW Management Subjects

Multivariate analysis was used to carry out a between subjects multiple comparison analysis of MSW management activities amongst the three respondents groups (households, businesses and policymakers) as outlined in Table 5.43. N represents the number of responses (from this table N shows indication of unequal cell sizes). Table 5.44 is the output from the analysis outlining three key descriptive statistical parameters: mean, standard deviation and number of responses from each group with respect to waste minimization knowledge, recycling knowledge, composting knowledge and the operations of AEPB.

Table 5.43: Between-Subjects Factors

		Value Label	N
type of respondent	1	households	1132
	2	businesses	193
	3	policymakers	144

Respondents were asked in question A3 in the questionnaire to use a scale of 1- 6 (1 = excellent, 6 = poor) to measure their knowledge of waste prevention subjects such as waste minimization, recycling, composting etc. From Table 5.43, total number of responses received from respondents on this question were 1132, 193 and 144 for households, businesses and policy makers, respectively. Overall, a total of 1469 responses were received from all three groups. From Table 5.44, policy makers had the best understanding of waste minimization with a mean score of 2.4 in a scale of 1-6. They are followed by households with a mean of 3.5. In all, on a scale of 1-6, average knowledge of residents of Abuja on waste minimization is around 3.4 (this reflects a fair, tending towards poor, knowledge).

Equally policy makers had the best recycling knowledge of all three groups studied at a calibrated mean of 2.9. Businesses again had the worst knowledge of all three groups at a mean of 4.2. Average mean for recycling was 3.6 with a standard deviation of 2.2, again reflecting a fair tending toward poor knowledge of recycling in the City.

Policy makers predictably had the best knowledge of composting and the operations of AEPB as well, at means of 2.5 and 2.8, respectively. In this respect, businesses equally had the worst knowledge with means of 4.1 and 3.6 for composting and the operations of the AEPB, respectively. In general, only policy makers could be said to possess the level of understanding of these subjects that is above average.

5.3.2.1: Between Subject Analysis of Variance of Knowledge of MSW Management Subjects

Table 5.45 is an Analysis of Variance in level of knowledge of the listed MSW subjects (dependent variables) between the respondent groups. Each item in the model is tested for its ability to account for variation on the dependent variables. The significance value (P) for each term is less than 0.05 ($P < 0.05$). This implies that there actually exists a significant statistical variation in the level of knowledge between the respondent groups on the listed MSW subjects.

Table 5.44: Descriptive statistical analysis

	type of respondent	Mean	Std. Deviation	N
Waste minimization knowledge	households	3.48	1.940	1132
	businesses	3.99	1.931	193
	policymakers	2.40	1.464	144
	Total	3.44	1.935	1469
Recycling knowledge	households	3.53	2.181	1132
	businesses	4.18	2.173	193
	policymakers	2.92	1.762	144
	Total	3.56	2.162	1469
Composting knowledge	households	3.53	2.090	1132
	businesses	4.12	2.127	193
	policymakers	2.51	1.954	144
	Total	3.51	2.116	1469
Abuja environmental protection board	households	3.24	1.871	1132
	businesses	3.46	2.148	193
	policymakers	2.83	1.766	144
	Total	3.23	1.905	1469

Table 5.45: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Waste mini. Knowld.	217.406[a]	2	108.703	30.198	<0.001
	recycling knowld.	133.569[b]	2	66.785	14.547	<0.001
	Composting knowld.	216.008[c]	2	108.004	24.914	<0.001
	AEPB	33.155[d]	2	16.577	4.592	0.010
Intercept	Waste mini. Knowld.	7486.324	1	7486.324	2079.732	<0.001
	recycling knowld.	8701.319	1	8701.319	1895.282	<0.001
	Composting knowld.	7942.235	1	7942.235	1832.095	<0.001
	AEPB	6992.146	1	6992.146	1936.922	<0.001
Respondent	Waste mini. Knowld.	217.406	2	108.703	30.198	<0.001
	recycling knowld.	133.569	2	66.785	14.547	<0.001
	Composting knowld.	216.008	2	108.004	24.914	<0.001
	AEPB	33.155	2	16.577	4.592	0.010
Error	Waste mini. Knowld.	5277.098	1466	3.600		
	recycling knowld.	6730.469	1466	4.591		
	Composting knowld.	6355.193	1466	4.335		
	AEPB	5292.152	1466	3.610		
Total	Waste mini. Knowld.	22910.000	1469			
	recycling knowld.	25477.000	1469			
	Composting knowld.	24626.000	1469			
	AEPB	20665.000	1469			
Corrected Total	Waste mini. Knowld.	5494.504	1468			
	recycling knowld.	6864.038	1468			
	Composting knowld.	6571.201	1468			
	AEPB	5325.307	1468			

a. R Squared = 0.040 (Adjusted R Squared = 0.038)

b. R Squared = 0.019 (Adjusted R Squared = 0.018)

c. R Squared = 0.033 (Adjusted R Squared = 0.032)

d. R Squared = 0.006 (Adjusted R Squared = 0.005).

5.3.2.2: Estimated marginal mean and standard error

Table 5.46 below displays the model–estimated marginal means and standard errors at 95% confidence interval, of respondents' level of knowledge on waste minimization, recycling, composting and AEPB. Table 5.47 presents an outline of grand mean for the dependent variables. From Table 5.46, it is possible to explore interaction effects between all three factors (households, businesses and policy makers). While households' level of waste minimization knowledge for instance, is at a mean of 3.5, policy makers have a much higher mean of 2.4. This trend is generally typical of all four variables indicating a major differential in the level of knowledge; thus suggests an interaction effect between level of waste management knowledge and occupation or the socio-economic status of respondents.

Table 5.46: Model estimated marginal means and standard error

Dependent Variable	type of respondent	Mean	Std. Error	95% Confidence Interval	
				Lower Boundary	Upper Boundary
Waste minimization knowledge	households	3.483	0.056	3.373	3.594
	businesses	3.990	0.137	3.722	4.258
	policymakers	2.396	0.158	2.086	2.706
Recycling knowledge	households	3.534	0.064	3.410	3.659
	businesses	4.181	0.154	3.879	4.484
	policymakers	2.924	0.179	2.573	3.274
Composting knowledge	households	3.527	0.062	3.405	3.648
	businesses	4.124	0.150	3.830	4.418
	policymakers	2.514	0.174	2.174	2.854
Abuja environmental protection board	households	3.243	0.056	3.132	3.354
	businesses	3.461	0.137	3.193	3.729
	policymakers	2.833	0.158	2.523	3.144

Table 5.47: Outline of grand mean

Dependent Variable	Mean	Std. Error	95% Confidence Interval	
			Lower Boundary	Upper Boundary
Waste minimization knowledge	3.290	0.072	3.148	3.431
Recycling knowledge	3.546	0.081	3.387	3.706
Composting knowledge	3.388	0.079	3.233	3.544
Abuja Environmental Protection Board	3.179	0.072	3.037	3.321

5.3.2.3: Post-Hoc Test

Though the test of between subjects effects (Table 5.45) helped to determine the statistical significance of variance between the factors, it did not indicate the actual point of variation; it was therefore necessary to carry out a post-hoc test. The post-hoc test result in Table 5.48 shows the differences in model predicted means for each pair of factor levels. Columns 2 and 3 of the table display the pairs of factors being tested. Where P value (column 6) is less than 0.05, variation in the means between factors is said to be statistically significant. There appears to be a strong statistical variation in the mean for respondents in this test, except for the variable, AEPB operations knowledge which showed no variation in mean between households and businesses. The post-hoc test suggest that there is indeed need to carry out a sustained public education programme on waste prevention both to bridge the variation in the level of knowledge amongst the groups as well as raise the overall knowledge of all respondent groups on waste prevention subject.

5.3.3: Analysis of Responses to Question A4: Measuring Respondents' Performance in MSW Management Subjects

Multivariate analysis was used to carry out a between subjects multiple comparison of actual performance of respondents groups on environmental sanitation, recycling and composting. Breakdown of responses received on this question is as outlined in Table 5.49 below. N represents the number of responses per factor. From this table N shows indication of unequal cell sizes. Table 5.50 is an SPSS analysis output showing three key descriptive statistical parameters: mean, standard deviation and number of responses (N) for each factor with

respect to environmental sanitation performance, recycling performance and composting performance.

Respondents were asked to use a scale of 1- 6 (where 1 = excellent performance and 6 = poor performance) to measure their performance in the listed waste prevention subjects. From Table 5.50, number of responses received from respondents on this question were 1127, 200 and 142 for households, businesses and policy makers, respectively. Overall, a total of 1469 responses were received from all three groups. From Table 5.50, policy makers performed best in environmental sanitation with a mean of 2.4, followed by businesses with a mean of 2.5. In all, on a scale of 1- 6, average performance of all respondents was around 2.6 (this reflects a status of good to excellent performance in environmental sanitation).

Table 5.48: Post-hoc tests

Dependent Variable	(I) type of respondent	(J) type of respondent	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Boundary	Upper Boundary
Waste mini. knowl	households	businesses	-0.51*	0.148	0.002	-0.85	-0.16
		policymakers	1.09*	0.168	<0.001	0.69	1.48
	businesses	households	0.51*	0.148	0.002	0.16	0.85
		policymakers	1.59*	0.209	<0.001	1.10	2.08
	policymakers	households	-1.09*	0.168	<0.001	-1.48	-0.69
		businesses	-1.59*	0.209	<0.001	-2.08	-1.10
recycling knowledge	households	businesses	-0.65*	0.167	<0.001	-1.04	-0.26
		policymakers	0.61*	0.190	0.004	0.17	1.06
	businesses	households	0.65*	0.167	<0.001	0.26	1.04
		policymakers	1.26*	0.236	<0.001	0.70	1.81
	policymakers	households	-0.61*	0.190	0.004	-1.06	-0.17
		businesses	-1.26*	0.236	<0.001	-1.81	-0.70
composting knowledge	households	businesses	-0.60*	0.162	<0.001	-0.98	-0.22
		policymakers	1.01*	0.184	<0.001	0.58	1.44
	businesses	households	0.60*	0.162	<0.001	0.22	0.98
		policymakers	1.61*	0.229	<0.001	1.07	2.15
	policymakers	households	-1.01*	0.184	<0.001	-1.44	-0.58
		businesses	-1.61*	0.229	<0.001	-2.15	-1.07
Abuja environmental protection board	households	businesses	-0.22	0.148	0.303	-0.57	0.13
		policymakers	0.41*	0.168	0.040	0.02	0.80
	businesses	households	0.22	0.148	0.303	-0.13	0.57
		policymakers	0.63*	0.209	0.008	0.14	1.12
	policymakers	households	-0.41*	0.168	0.040	-0.80	-0.02
		businesses	-0.63*	0.209	0.008	-1.12	-0.14

Based on observed means.

The error term is Mean Square (Error) = 3.610.

*. The mean difference is significant at the 0.05 level.

Table 5.49: Between-Subjects Factors

		Value Label	N
type of respondent	1	households	1127
	2	businesses	200
	3	policymakers	142

Policy makers as well, performed better than the other two groups in recycling with a mean of 2.7. In this instance, households were second best performers while businesses were worst performers in recycling at a mean value of 4.1 Average mean for recycling performance was 3.7 with a standard deviation of 1.6. Overall, this again reflects a fair tending toward poor performance in recycling by all three groups.

Policy makers also performed best in composting with a mean of 2.5. In this respect however, businesses performed worse than all three groups with a mean of 3.8. Overall, only policy makers could be said to have a good performance rating.

Table 5.50: Descriptive statistical analysis

	type of respondent	Mean	Std. Deviation	N
environmental sanitation performance	households	2.71	1.647	1127
	businesses	2.62	1.744	200
	policymakers	2.02	1.246	142
	Total	2.63	1.638	1469
recycling performance	households	3.76	2.152	1127
	businesses	4.11	2.255	200
	policymakers	2.70	2.263	142
	Total	3.71	2.204	1469
composting performance	households	3.58	2.170	1127
	businesses	3.82	2.433	200
	policymakers	2.49	2.262	142
	Total	3.51	2.241	1469

Table 5.51 is an Analysis of Variance of the three factors. Each item in the model was tested for its ability to account for variation on the dependent variables. Where sample size is represented by N, degree of freedom, df is calculated as (N-1), while the ratio of mean square deviation is given as the (F) statistic. From the table, the significance level (P), for each term is less than 0.05 ($P<0.05$) indicating strong statistically significant variations.

Table 5.51: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	environmental sanitation performance	59.715[a]	2	29.857	11.285	<0.001
	recycling performance	180.717[b]	2	90.359	19.060	<0.001
	composting performance	173.994[c]	2	86.997	17.716	<0.001
Intercept	environmental sanitation performance	4172.633	1	4172.633	1577.042	<0.001
	recycling performance	8640.033	1	8640.033	1822.533	<0.001
	composting performance	7561.924	1	7561.924	1539.873	<0.001
Respondent	environmental sanitation performance	59.715	2	29.857	11.285	<0.001
	recycling performance	180.717	2	90.359	19.060	<0.001
	composting performance	173.994	2	86.997	17.716	<0.001
Error	environmental sanitation performance	3878.831	1466	2.646		
	recycling performance	6949.829	1466	4.741		
	composting performance	7199.150	1466	4.911		
Total	environmental sanitation performance	14097.000	1469			
	recycling performance	27313.000	1469			
	composting performance	25456.000	1469			
Corrected Total	environmental sanitation performance	3938.546	1468			
	recycling performance	7130.546	1468			
	composting performance	7373.144	1468			

a. R Squared = 0 .015 (Adjusted R Squared = 0.014)

b. R Squared = 0.025 (Adjusted R Squared = 0.024)

c. R Squared = 0.024 (Adjusted R Squared = 0.022).

Table 5.52 below displays the model – estimated marginal means and standard errors at 95% confidence interval, of respondents' performance on environmental sanitation, recycling and composting. Table 5.53 represents an outline of grand mean for the dependent variables. From Table 5.52, it is possible to explore the interaction effect between the factors and dependent variables. While households' performance in environmental sanitation for instance is at a mean of 2.7, policy makers have a much higher mean of 2.0 for the same variable. This underlines the fact that there is a major differential in performance levels suggesting an interaction effect between actual performance in MSW management subjects and socio-economic status of respondents.

Table 5.52: Model estimated marginal means and standard error

Dependent Variable	type of respondent	Mean	Std. Error	95% Confidence Interval	
				Lower Boundary	Upper Boundary
environmental sanitation performance	households	2.709	0.048	2.614	2.804
	businesses	2.615	0.115	2.389	2.841
	policymakers	2.021	0.137	1.753	2.289
recycling performance	households	3.762	0.065	3.635	3.889
	businesses	4.110	0.154	3.808	4.412
	policymakers	2.697	0.183	2.339	3.056
composting performance	households	3.582	0.066	3.453	3.712
	businesses	3.820	0.157	3.513	4.127
	policymakers	2.486	0.186	2.121	2.851

Table 5.53: Outline of grand mean

Dependent Variable	Mean	Std. Error	95% Confidence Interval	
			Lower Boundary	Upper Boundary
environmental sanitation performance	2.448	0.062	2.327	2.569
recycling performance	3.523	0.083	3.361	3.685
composting performance	3.296	0.084	3.131	3.461

Though the test of between subject effects helped to determine the statistical significance of the level of variation between factors, it did not indicate how these factors actually differed. To obtain this information, a post-hoc test was carried out. The post-hoc test result in Table 5.54 shows the differences in model predicted means for each pair of factor levels. Columns 2 and 3 display the pairs of factors being tested. Where $P<0.05$, variation in their means is said to be statistically significant. From Table 5.54, there is a variation in environmental performance. Actual point of variation in environmental performance is between households and policy makers. There was equally a statistically significant variation between businesses and policy makers. Variation in performance between households and businesses was not statistically significant.

In recycling performance, there was a statistically significant variation between households and policy makers as well as between policy makers and businesses. Just as in environmental sanitation, the level of variation between households and businesses was not statistically significant.

Equally in composting, there was a statistically significant variation in performance between households and policy makers as well as between policy makers and businesses. Variations in recycling performance between households and businesses were not statistically significant or could have arisen purely by chance or error.

5.3.4: Analysis of responses to question 22: barriers to sustainable MSW management

Multivariate analysis was used to carry out a between subjects multiple comparison analysis of barriers to MSW management in Abuja. A breakdown of responses received on this question is as outlined in Table 5.55 below. N represents the number of responses per factor. From this table N shows indication of unequal cell sizes. Table 5.56 is an SPSS analysis output showing three key descriptive statistical parameters: mean, standard deviation and number of responses (N) for the listed barriers affecting sustainable management of MSW in the City.

Table 5.54: Post-hoc tests (multiple comparisons)

Dependent Variable	(I) type of respondent	(J) type of respondent	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Boundary	Upper Boundary
environmental sanitation performance	households	businesses	0.09	0.125	0.732	-0.20	0.39
		policymakers	0.69*	0.145	<0.001	0.35	1.03
	businesses	households	-0.09	0.125	0.732	-0.39	0.20
		policymakers	0.59*	0.178	0.003	0.18	1.01
	policymakers	households	-0.69*	0.145	<0.001	-1.03	-0.35
		businesses	-0.59*	0.178	0.003	-1.01	-0.18
recycling performance	households	businesses	-0.35	0.167	0.094	-0.74	0.04
		policymakers	1.07*	0.194	<0.001	0.61	1.52
	businesses	households	0.35	0.167	0.094	-0.04	0.74
		policymakers	1.41*	0.239	<0.001	0.85	1.97
	policymakers	households	-1.07*	0.194	<0.001	-1.52	-0.61
		businesses	-1.41*	0.239	<0.001	-1.97	-0.85
composting performance	households	businesses	-0.24	0.170	0.342	-0.64	0.16
		policymakers	1.10*	0.197	<0.001	0.63	1.56
	businesses	households	0.24	0.170	0.342	-0.16	0.64
		policymakers	1.33*	0.243	<0.001	0.76	1.90
	policymakers	households	-1.10*	0.197	<0.001	-1.56	-0.63
		businesses	-1.33*	0.243	<0.001	-1.90	-0.76

Based on observed means.

The error term is Mean Square (Error) = 4.911.

*. The mean difference is significant at the 0.05 level.

Table 5.55: Between-Subjects Factors

		Value Label	N
type of respondent	1	households	1136
	2	businesses	192
	3	policymakers	141

Table 5.56 column 1 lists the 10 identified barriers affecting sustainable MSW management in the City while columns 2 and 3 are lists of corresponding respondents and mean values respectively. On barrier no. 1, “waste policies lack clear strategies for action,” both households and businesses ranked this barrier at level 3.47. Policy makers however ranked it slightly lower at 3.12. Calculated mean rank of the barrier is 3.44. Standard deviations from mean are generally homogeneous approaching a value of 2.0.

On barrier no. 2 “legal framework is weak,” households ranked this barrier at 3.57, businesses, 3.75, while policy makers ranked it slightly lower at 3.12. Calculated mean rank for this barrier is 3.55. Standard deviations from mean generally approach a value of 2.0.

On barrier no. 3, “waste management institutions are weak,” both households and businesses ranked this barrier at level 3.85 and 3.84, respectively. Policy makers however ranked it slightly lower at 2.91. Calculated mean rank of the barrier is 3.76. Standard deviations from mean are generally homogeneous, approaching a value of 2.0.

On barrier no. 4, “unplanned City aspects make waste collection difficult”, households ranked this barrier at 3.46 while businesses ranked same at level 3.56. Policy makers however ranked it slightly higher than all three groups at 3.64. Calculated mean rank for this barrier is 3.49. Standard deviations from mean is about 2.1

On barrier no. 5, “density and high moisture content makes waste difficult to manage”, households ranked this barrier at 3.34 while businesses ranked same at level 3.31. Policy makers on the other hand ranked it slightly lower than both groups at 3.09. Calculated mean rank for this barrier is 3.29. Standard deviations from mean is about 2.0

On barrier no. 6, “availability of dumping grounds discourages expensive investment in alternative disposal methods”, households ranked this barrier at 3.35 while businesses ranked it at level 3.69. Policy makers on the other hand ranked this barrier much lower than both groups at 2.77. Calculated mean rank for this barrier is 3.34. Standard deviations from mean are generally homogeneous approaching a value of about 2.1.

On barrier no. 7, “funding limitations”, households ranked this barrier at 3.95 while businesses ranked same barrier much higher at level 4.69. Policy makers on the other hand ranked this barrier much lower than both groups at 3.21. Calculated mean rank for this barrier is 3.97. Standard deviations from mean are generally homogeneous approaching a value of about 2.1

On barrier no. 8, “public education on waste management is low”, households ranked this barrier at 4.47 while businesses ranked same barrier much higher at level 4.72. Policy makers on the other hand ranked this barrier much lower than both groups at 3.96. Calculated mean rank for this barrier is 4.46. Standard deviations from mean are generally homogeneous approaching a value of about 2.0

On barrier no. 9, “waste workers are poorly trained and poorly paid”, households ranked this barrier at 4.01 while businesses ranked same barrier much higher at level 4.69. Policy makers on the other hand ranked this barrier at 4.08. Calculated mean rank for this barrier is 4.11. Standard deviations from mean are generally homogeneous approaching a value of about 2.2

On barrier no. 10, “operational equipment are obsolete and insufficient”, households ranked this barrier at 4.19 while businesses ranked same barrier slightly higher at level 4.42. Policy makers on the other hand ranked this barrier at 4.30. Calculated mean rank for this barrier is 4.23. Standard deviations from mean are generally homogeneous approaching a value of about 2.0

Appendix 9 is an analysis of variance between the three respondent groups. Each item in the model is tested for its ability to account for variation on the dependent variables. Where sample size is represented by N, degree of freedom, df is (N-1) while the ratio of mean square deviation is given as the (F) statistic. Where the significance level (P), for each term is less than 0.05 ($P < 0.05$) there is an indication of a strong statistical variation.

Table 5.56: Descriptive statistical analysis

	Type of respondent	Mean	Std. Deviation	N
Policies lack clear strategies	households	3.47	1.975	1136
	businesses	3.47	2.180	192
	policymakers	3.13	1.661	141
	Total	3.44	1.977	1469
Legal framework is weak	households	3.57	2.036	1136
	businesses	3.75	2.064	192
	policymakers	3.12	1.632	141
	Total	3.55	2.009	1469
Waste institutions	households	3.85	1.977	1136
	businesses	3.84	1.924	192
	policymakers	2.91	1.933	141
	Total	3.76	1.984	1469
Unplanned City aspects	households	3.46	2.170	1136
	businesses	3.56	2.010	192
	policymakers	3.64	2.262	141
	Total	3.49	2.158	1469
Waste has high density & moisture content	households	3.34	2.035	1136
	businesses	3.13	1.973	192
	policymakers	3.09	1.929	141
	Total	3.29	2.018	1469
Availability of dumping grounds	households	3.35	2.100	1136
	businesses	3.69	2.165	192
	policymakers	2.77	2.195	141
	Total	3.34	2.128	1469
Funding limitations	households	3.95	2.134	1136
	businesses	4.67	1.879	192
	policymakers	3.21	2.194	141
	Total	3.97	2.135	1469
Low level public education on waste mgt	households	4.47	1.987	1136
	businesses	4.72	2.019	192
	policymakers	3.96	2.236	141
	Total	4.46	2.023	1469
Waste workers poorly paid & trained	households	4.01	2.191	1136
	businesses	4.69	2.217	192
	policymakers	4.08	2.302	141
	Total	4.11	2.215	1469
Obsolete and insufficient operational equipment	households	4.19	2.073	1136
	businesses	4.42	2.040	192
	policymakers	4.30	2.194	141
	Total	4.23	2.081	1469

Table 5.57: Model estimated marginal means and standard error

Dependent Variable	type of respondent	Mean	Std. Error	95% Confidence Interval	
				Lower Boundary	Upper Boundary
Policies lack clear strategies	households	3.469	0.059	3.354	3.584
	businesses	3.469	0.143	3.189	3.748
	policymakers	3.135	0.166	2.808	3.461
Legal framework is weak	households	3.573	0.059	3.456	3.690
	businesses	3.750	0.145	3.466	4.034
	policymakers	3.121	0.169	2.789	3.452
Waste institutions	households	3.849	0.058	3.734	3.963
	businesses	3.844	0.142	3.565	4.122
	policymakers	2.915	0.166	2.590	3.240
Unplanned City aspects	households	3.460	0.064	3.334	3.585
	businesses	3.557	0.156	3.252	3.863
	policymakers	3.638	0.182	3.282	3.995
Waste has high density & moisture content	households	3.339	0.060	3.222	3.456
	businesses	3.130	0.146	2.845	3.416
	policymakers	3.085	0.170	2.752	3.418
Availability of dumping grounds	households	3.349	0.063	3.226	3.473
	businesses	3.688	0.153	3.388	3.987
	policymakers	2.773	0.178	2.423	3.123
Funding limitations	households	3.945	0.063	3.823	4.068
	businesses	4.672	0.152	4.373	4.970
	policymakers	3.213	0.178	2.865	3.561
Low level public education on waste mgt	households	4.474	0.060	4.356	4.591
	businesses	4.719	0.146	4.433	5.004
	policymakers	3.957	0.170	3.624	4.291
Waste workers poorly paid & trained	households	4.010	0.065	3.881	4.138
	businesses	4.693	0.159	4.381	5.005
	policymakers	4.078	0.186	3.714	4.442
Obsolete and insufficient operational equipment	households	4.194	0.062	4.073	4.315
	businesses	4.422	0.150	4.127	4.716
	policymakers	4.305	0.175	3.961	4.649

Table 5.57 above displays the model–estimated marginal means and standard errors at 95% confidence interval. The table explores the interaction effect between the dependent variables (barriers) and respondent groups. The upper and lower values for each variable have been estimated and mean value calculated. Table 5.58 is an outline of grand means for each dependent variable (barrier) at 95% confidence interval, while Figure 5.7 is a graphical plot of calculated grand mean values against the dependent variables (barriers). Table 5.59 ranks these barriers by order of importance (i.e. magnitude of grand mean values). From Figure 5.7 and Table 5.59, the most important barrier constraining sustainable waste management in Abuja (No.1) is the very low level of public education on MSW management. Equally, the least important barrier (No.10) constraining sustainable MSW management is the character of waste from the City (high density and moisture content).

Table 5.58: Outline of grand mean

Dependent Variable	Mean	Std. Error	95% Confidence Interval	
			Lower Boundary	Upper Boundary
Policies lack clear strategies	3.358	0.076	3.209	3.506
Legal framework is weak	3.481	0.077	3.331	3.632
Waste institutions	3.536	0.075	3.388	3.683
Unplanned City aspects	3.552	0.083	3.390	3.714
Waste has high density & moisture content	3.185	0.077	3.033	3.336
Availability of dumping grounds	3.270	0.081	3.111	3.429
Funding limitations	3.943	0.081	3.785	4.102
Low level public education on waste mgt	4.383	0.077	4.232	4.535
Waste workers poorly paid & trained	4.260	0.084	4.095	4.426
Obsolete and insufficient operational equipment	4.307	0.080	4.151	4.463

A Tukey HSD post-hoc test was carried out to ascertain at what points the variances discussed in the test of between subjects effect (Table 5.51) actually occurred. Appendix 10 outlines results of this post-hoc test. Columns 2 and 3 in the table represent the pairs of factors being tested. Where $P < 0.05$, variation is said to be statistically significant.

From Appendix 10, it can be seen that on the variable "legal framework is weak", there was significant variation between households and policy makers as well as between businesses and policy makers. On the variable "waste institutions are weak" statistically significant variations in responses were found to exist between households and policy makers; the variation between household and businesses was found to be insignificant. There was equally a significant variation between policy makers and businesses.

Post-hoc tests found no statistically significant variation between the respondent groups on the variables "unplanned aspects of the City make MSW management difficult", as well as on "waste has high density and moisture content". Significant variations were however found to exist between households and policy makers and between policy makers and businesses on the variable "availability of dumping grounds discourages expensive investment in sustainable disposal methods."

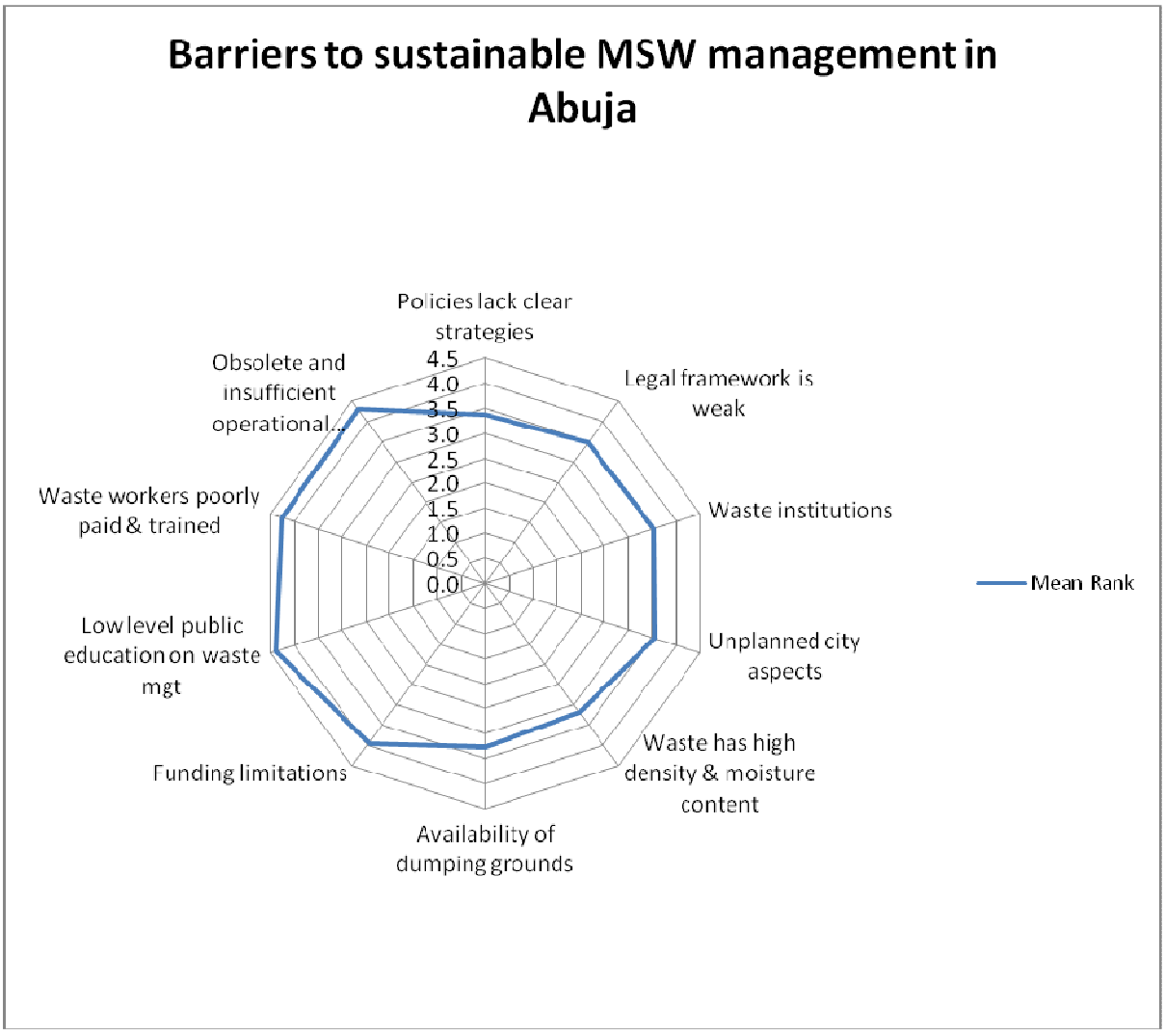

Figure 5.7: Graphical plot of the barriers affecting sustainable MSW management.

There were significant variations between all three respondent groups on the variable "funding limitations". On how low level of public education is constraining sustainable MSW management in the City, significant variation in responses occurred between households and policy makers as well as between policy makers and businesses. There was either no variation between households and businesses or any variation observed was purely by chance.

On "waste workers are poorly paid and trained", while variation between households and businesses was significant, no significant variation was found between household and policy makers. On the other hand, a significant variation was discovered between policy makers and businesses. No significant variation was found in the responses of all three respondents groups on the barrier "obsolete and insufficient operational equipment constrains sustainable MSW management in the City of Abuja."

Table 5.59: Ranking of barriers by order of importance

Barrier	Mean (rank)
1. Low level public education on MSW management	4.383
2. Obsolete and insufficient operational equipment	4.307
3. Waste workers poorly paid & trained	4.260
4. Funding limitations	3.943
5. Unplanned City aspects makes waste collection difficult	3.552
6. Waste institutions are weak	3.536
7. Legal framework is weak	3.481
8. Policies lack clear strategies for action	3.358
9. Availability of dumping grounds encourages waste dumping	3.270
10. High density and moisture content makes waste difficult to manage	3.185

5.3.5: Analysis of Responses to Question 24: Success Factors Affecting Sustainable MSW Management

Multivariate analysis was used to carry out a between subjects multiple comparison analysis of success factors affecting MSW management in Abuja. A breakdown of responses received on this question is outlined in Table 5.60 below. N represents the number of responses per factor. From this table N shows indication of unequal cell sizes. Table 5.61 is an SPSS analysis output showing three key descriptive statistical parameters: mean, standard deviation and number of responses (N) for the listed success factors affecting sustainable management of MSW in the City.

Table 5.60: Between-Subjects Factors

		Value Label	N
type of respondent	1	households	1153
	2	businesses	190
	3	policymakers	150

Respondents were asked to use a scale of 1- 6 (where 1 = success factor has minor effect and 6 = success factor has major effect) to categorize the listed success factors affecting MSW management in Abuja. From Table 5.60, number of responses received from respondents on this question were 1153, 190 and 150 for households, businesses and policy makers, respectively. Overall, a total of 1493 responses were received from all three groups.

Table 5.61 column 1, lists four identified success factors affecting sustainable MSW management in the City. Columns 2 and 3 are lists of corresponding respondents and mean values respectively. On factor no. 1, “culture of informal recycling already exists”, households ranked this success factor at level 3.05 while businesses ranked it at 3.00. Policy makers ranked it slightly lower at 2.82. Calculated mean rank for this success factor is 3.02. Standard deviation from mean generally approaches a value of 2.0.

On factor no. 2 “waste stream is compostable” households ranked this factor at 3.08, businesses, 3.40, while policy makers ranked it slightly lower at 2.79. Calculated mean rank for this success factor is 3.09 while the standard deviation is 1.97.

On factor no. 3, “City population offers potential market for recycled products and compost”, households ranked this factor at level 3.79 while businesses ranked it slightly lower at 3.56 while policy makers ranked at 3.71. Calculated mean rank for this success factor is 3.75. Standard deviation from mean generally approaches a value of 2.1.

On factor no. 4, “recent emergence of small scale industries will encourage recycling”, households ranked this factor at level 3.35 while businesses ranked it slightly higher at 3.68. Policy makers however ranked much lower at 2.87. Calculated mean rank for this success factor is 3.34. Standard deviations from mean are homogeneous, generally approaching a value of 2.1.

Table 5.61: Descriptive statistical analysis

	type of respondent	Mean	Std. Deviation	N
Culture of informal recycling already exist	households	3.05	2.002	1153
	businesses	3.00	2.225	190
	policymakers	2.83	1.864	150
	Total	3.02	2.018	1493
Waste stream is compostable	households	3.08	1.959	1153
	businesses	3.40	2.170	190
	policymakers	2.79	1.762	150
	Total	3.09	1.973	1493
City population offers potential market	households	3.79	2.038	1153
	businesses	3.56	2.271	190
	policymakers	3.71	2.160	150
	Total	3.75	2.081	1493
Emergence of small scale industries	households	3.35	2.041	1153
	businesses	3.68	2.067	190
	policymakers	2.87	2.197	150
	Total	3.34	2.068	1493

Table 5.62 is an Analysis of Variance between the three respondent groups. Each item in the model is tested for its ability to account for variation on the dependent variables. Sample size is represented by N, degree of freedom; df is (N-1) while the ratio of mean square deviation is given as the (F) statistic. Where the significance level (P) is less than 0.05 ($P < 0.05$) there is an indication of a strong statistical variation.

Table 5.62: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	culture of informal recycling already exist	6.624[a]	2	3.312	0.813	0.444
	waste stream is compostable	31.625[b]	2	15.812	4.080	0.017
	City population offers potential market	8.916[c]	2	4.458	1.029	0.357
	emergence of small scale industries	55.554[d]	2	27.777	6.545	<0.001
Intercept	culture of informal recycling already exist	6155.273	1	6155.273	1510.739	<0.001
	waste stream is compostable	6717.030	1	6717.030	1733.001	<0.001
	City population offers potential market	9544.978	1	9544.978	2203.974	<0.001
	emergence of small scale industries	7653.911	1	7653.911	1803.486	<0.001
Respondent	culture of informal recycling already exist	6.624	2	3.312	0.813	0.444
	waste stream is compostable	31.625	2	15.812	4.080	0.017
	City population offers potential market	8.916	2	4.458	1.029	0.357
	emergence of small scale industries	55.554	2	27.777	6.545	<0.001
Total	culture of informal recycling already exist	6070.773	1490	4.074		
	waste stream is compostable	5775.168	1490	3.876		
	City population offers potential market	6452.897	1490	4.331		
	emergence of small scale industries	6323.490	1490	4.244		
Corrected Total	culture of informal recycling already exist	19695.000	1493			
	waste stream is compostable	20066.000	1493			
	City population offers potential market	27459.000	1493			
	emergence of small scale industries	23077.000	1493			

a. R Squared = 0.001 (Adjusted R Squared = <0.001)

b. R Squared = 0.005 (Adjusted R Squared = 0.004)

c. R Squared = <0.001 (Adjusted R Squared <0.001)

d. R Squared = 0.009 (Adjusted R Squared = 0.007).

Table 5.63 below displays the model – estimated marginal means and standard errors at 95% confidence interval. The table represents the interaction effect between the dependent variables (success factors) and respondent groups. The upper and lower bound for each variable as well as mean value have been calculated. Table 5.64 is an outline of grand means for each dependent variable (success factors) at 95% confidence interval. Figure 5.8 is a graphical plot of calculated grand mean values against the dependent variables (success factor). Table 5.65 is a categorization of these success factors by order of importance. From Figure 5.8 and Table 5.65 the most important success factor affecting sustainable waste management in Abuja is the perceived bourgeoning City population which has a huge potential for uptake of recycled products.

Table 5.63: Model estimated marginal means and standard error

Dependent Variable	type of respondent	Mean	Std. Error	95% Confidence Interval	
				Lower Boundary	Upper Boundary
culture of informal recycling already exist	households	3.049	0.059	2.932	3.165
	businesses	3.000	0.146	2.713	3.287
	policymakers	2.827	0.165	2.503	3.150
waste stream is compostable	households	3.078	0.058	2.964	3.192
	businesses	3.400	0.143	3.120	3.680
	policymakers	2.793	0.161	2.478	3.109
City population offers potential market	households	3.788	0.061	3.667	3.908
	businesses	3.558	0.151	3.262	3.854
	policymakers	3.707	0.170	3.373	4.040
emergence of small scale industries	households	3.351	0.061	3.232	3.470
	businesses	3.679	0.149	3.386	3.972
	policymakers	2.867	0.168	2.537	3.197

A Tukey HSD post-hoc test was carried out to discover at what points exactly the variances discussed in the test of between subjects effect (Table 5.62) actually occurred. Table 5.66 outlines results of this post-hoc test. Columns 2 and 3 list the variables being tested. Where $P < 0.05$, variation is said to be statistically significant. From Table 5.66, it can be seen that on the variable "culture of informal recycling already exist", there was no significant variation between the three respondent groups.

Table 5.64: Outline of grand mean

Dependent Variable	Mean	Std. Error	95% Confidence Interval	
			Lower Boundary	Upper Boundary
culture of informal recycling already exist	2.958	0.076	2.809	3.108
waste stream is compostable	3.090	0.074	2.945	3.236
City population offers potential market	3.684	0.078	3.530	3.838
emergence of small scale industries	3.299	0.078	3.147	3.451

On the variable "waste stream is compostable" statistically significant variations in responses exist between businesses and policy makers only. Post-hoc tests found no statistically significant variation between the respondent groups on the variables "City population offers potential market for recycling." Significant variations were however found to exist between households and policy makers and between policy makers and businesses on the variable "emergence of small scale industries." There was no variation between businesses and household on this variable.

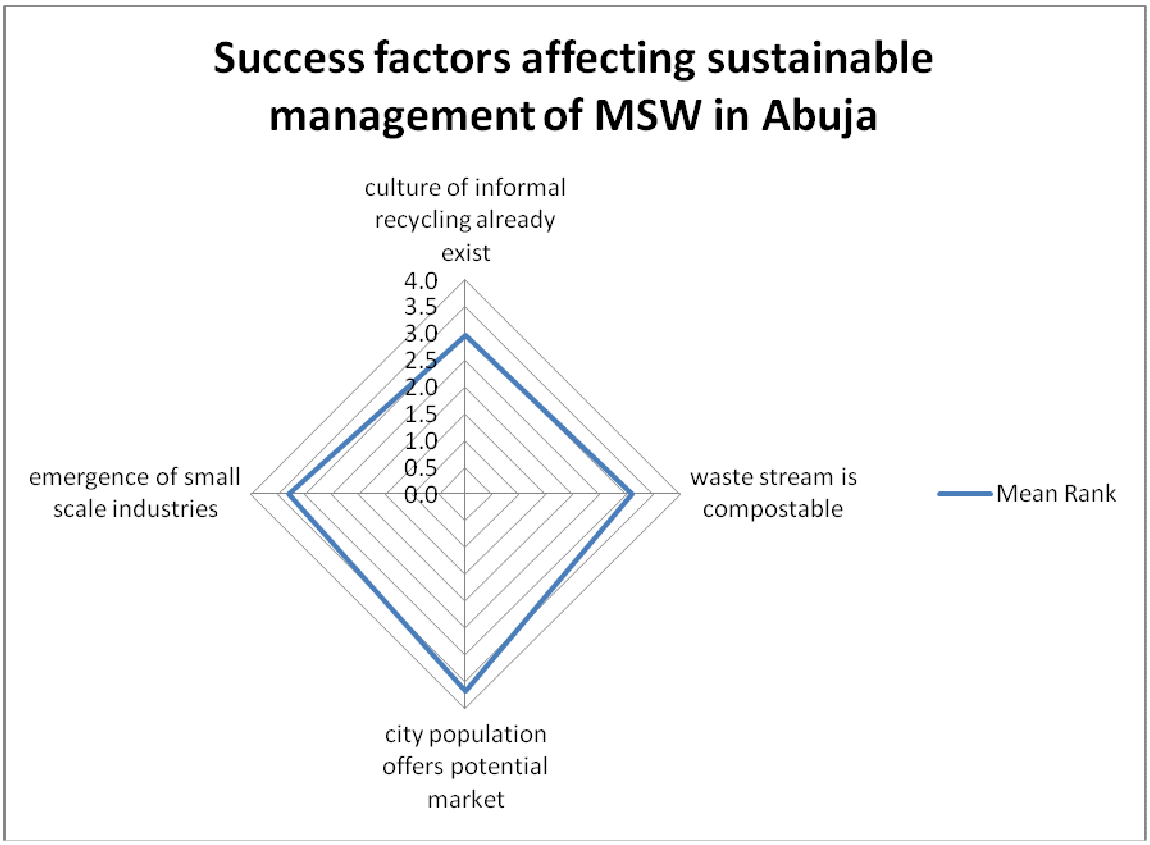

Figure 5.8: Graphical plot of success factors affecting sustainable MSW management.

Table 5.65: Ranking of success factors by order of importance

Success factors	Average mean rank
1. City population offers potential market	3.7
2. Emergence of small scale industries	3.3
3. Waste stream is compostable	3.1
4. Culture of informal recycling already exist	3.0

Table 5.66: Post-hoc tests (multiple comparisons)

Dependent Variable	(I) type of respondent	(J) type of respondent	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Boundary	Upper Boundary
Culture of informal recycling already exist	households	businesses	0.05	0.158	0.949	-0.32	0.42
		policymakers	0.22	0.175	0.414	-0.19	0.63
	businesses	households	-0.05	0.158	0.949	-0.42	0.32
		policymakers	0.17	0.220	0.712	-0.34	0.69
	policymakers	households	-0.22	0.175	0.414	-0.63	0.19
		businesses	-0.17	0.220	0.712	-0.69	0.34
Waste stream is compostable	households	businesses	-0.32	0.154	0.093	-0.68	0.04
		policymakers	0.28	0.171	0.219	-0.12	0.69
	businesses	households	0.32	0.154	0.093	-0.04	0.68
		policymakers*	0.61*	0.215	0.013	0.10	1.11
	policymakers	households	-0.28	0.171	0.219	-0.69	0.12
		businesses*	-0.61*	0.215	0.013	-1.11	-0.10
City population offers potential market	households	businesses	0.23	0.163	0.336	-0.15	0.61
		policymakers	0.08	0.181	0.895	-0.34	0.50
	businesses	households	-0.23	0.163	0.336	-0.61	0.15
		policymakers*	-0.15	0.227	0.790	-0.68	0.38
	policymakers	households	-0.08	0.181	0.895	-0.50	0.34
		businesses*	0.15	0.227	0.790	-0.38	0.68
Emergence of small scale industries	households	businesses	-0.33	0.161	0.105	-0.71	0.05
		policymakers	0.48*	0.179	0.019	0.07	0.90
	businesses	households	0.33	0.161	0.105	-0.05	0.71
		policymakers*	0.81*	0.225	<0.001	0.28	1.34
	policymakers	households	-0.48*	0.179	0.019	-0.90	-0.07
		businesses*	-0.81*	0.225	<0.001	-1.34	-0.28

Based on observed means.

The error term is Mean Square (Error) = 4.244.

*. The mean difference is significant at the 0.05 level.

5.4: Summary

A total of 1557 responses were returned by all three target groups surveyed in the main study. Of this number, 1204 responses, equivalent to 77.3% were from households, 200 responses (12.8%) were received from businesses, while 153 responses (9.8%) were received from waste policy makers.

To assist in the validation of outcomes of the main questionnaire survey, an online pilot survey was adapted using the Surveyor sampling software. This online questionnaire was then mailed to 250 Nigerian students at the University of Wolverhampton via the University's International Students' Office between June and July, 2008. A total of 57 responses were returned equivalent to about 23% response rate. Respondents were requested to identify the main barriers to sustainable MSW management in the City. Most respondents cited low public awareness/education on MSW management, obsolete and insufficient equipment and funding limitations as the main barriers to sustainable management of MSW in Abuja. Other major barriers as identified by respondents were on the issue of training and remuneration of waste workers and strengthening of waste management institutions, policies and strategies.

Respondents were asked to assess how the listed success factor in Table 5.3 affected waste management in Abuja using a sliding scale of 1 (minimal effect) and 6 (maximum effect). From the table the main success factor as identified by most respondents is that the large City population is a potential market for recycled products especially compost.

In the main survey, analysis of distribution of respondents according to residential districts or location of business shows that Asokoro district had the least number of respondents at just about 6.2% of total respondents. Maitama, Central Area and Garki districts had 8.6%, 9.4% and 19.5%, respectively. The district with the highest number of respondents in the survey was Wuse at 25.7%. Approximately 30% of the respondents came from satellite towns outside the municipal area, thus validating results from the pilot survey which also showed a similar percentage of respondents.

Garki and Wuse districts have the highest number of households earning less than 7500 Nigerian Naira monthly, at 14% and 9%, respectively. The Central Area and Maitama on the other hand have the least numbers of low income households at 0% and 2%, respectively. The highest concentration of mid income (30,000-100,000 per month) households are in Garki and the satellite towns. Maitama, Central Area and Asokoro have the highest concentration of high income households in the City.

A geo-demographic classification of the case study area shows that Garki District has the highest concentration of hard pressed and moderate means (poor neighbourhoods) at 8% and 35%, respectively. Garki and Wuse districts account for the largest concentrations of mid income neighbourhoods (the comfortably offs) as well. However, Maitama and Asokoro could be described as largely consisting of neighbourhoods for wealthy achievers and prosperous urban dwellers.

An assessment of respondents' level of knowledge of waste management subjects such as waste minimization, recycling, composting and the operations of the AEPB shows that approximately 47% of respondents said they had good to excellent knowledge of waste minimization, while about 48% of respondents evaluated their knowledge of waste minimization to be between fair and very poor. Approximately 37% of respondents said they had good to excellent knowledge of recycling. On the other hand about 52% of respondents evaluated their understanding of recycling to be between fair and very poor. Approximately 34% of respondents said they had good to excellent knowledge of composting. This percentage compares poorly with about 53% of respondents who evaluated their understanding of composting to be between fair and very poor. Approximately 53% of respondents said they had good to excellent knowledge of AEPB operations. Likewise, about 41% of respondents evaluated their understanding of AEPB operations to be between fair and very poor.

Performance of respondents on MSW related subjects such as environmental sanitation, recycling/reuse and composting was also measured. Approximately 69.7% of respondents rated their environmental sanitation performance between good to excellent. Conversely, about 25% of respondents evaluated their performance on environmental sanitation to be between fair and very poor. Approximately 26% of respondents rated their recycling/reuse performance between good to excellent. On the other hand, nearly 60% of respondents evaluated their recycling/reuse performance to be between fair and very poor. If 14.9% respondents who were not sure of their response to the question were taken into consideration, the percentage of poor performers in recycling could be as high as 75% of respondents. Composting performance did not fare much better. While approximately 28% of respondents rated their composting performance between good to excellent, nearly 55% of respondents evaluated their composting performance to be between fair and very poor.

Analysis of waste generation and collection showed that weekly rates of MSW generation per household can be summarized as follows: (1) 21.2% of respondents generated more than 240 L by volume of MSW per week (2) 26.8% of respondents said they generated less than 240 L by volume of MSW per week (3) 16.1% of respondents said they generated more than a black bin bag of MSW per week from their household (4) 9.2% of respondents said they generated less than a black bin bag

of MSW per week, while another 26.7% of respondents said the volume of MSW they generated weekly varied widely. A chi square test of the relationship between household income and waste generation rate indicates that while there is a positive relationship between household income and waste arising, the relationship may not necessarily be linear in all cases. Analysis also showed that 56% of residents of Central Area District use 240 L plastic receptacles for waste collection as compared to Garki district at 39%. Only 3% of Maitama residents use open containers for waste collection. Open containers are mostly used by households in the satellite towns (14%), and poorer neighbourhoods of Garki (8%) and Wuse (8%). Apart from open containers, these districts also mostly utilize communal facilities for waste collection.

Considering the main waste collection agents in the City, results indicate that 33.3% of total MSW arising in the City is collected directly by AEPB from schools, offices and government establishment. Approximately 41% of MSW arising from the City are collected by waste contractors who have jurisdiction over waste collection zones. Other waste collection agencies in the City include scavengers and family members. Waste collected by scavengers account for about 9.9% of total waste arising from the City, while about 12.2% of total MSW arising in the City is collected directly by household members. An outline of average monthly expense on MSW services per household shows that about 35.7% of residents of Abuja pay less than 500 Naira per month for MSW management services they receive. At current exchange rates (250.38 N/£ as at 05/12/2009), this would imply that more than a third of Abuja residents pay less than £2 per month for waste collection and disposal services. It was also discovered that while 73% of those earning under 7,500 Naira monthly spent about 7% of net monthly income on waste services, over 50% of middle income earners (30,000-100,000 Naira/month) spent just about 1% of net monthly income on waste services; implying that in absolute terms, wealthier residents tended to pay less for waste services in the City. This situation impacts rather negatively on the financial position of the AEPB as they have had to rely consistently on government subvention for their operations over the years. A direct consequence of the precarious financial position of the AEPB, is diminishing operational capabilities. It was show in Section 5.2.6.6 that nearly a third of the total solid waste arising from the City does not find their way into the formal waste management route designed by the AEPB. Four principal MSW disposal routes were discussed: sanitary landfills, open dumping, burning and incineration. Open dumping and burning were, however, found to be the prevalent disposal methods as there were no engineered landfills or incinerators in the City presently

Multivariate Analysis of Variance indicates a strong, statistically significant variation between and within the three respondent groups in levels of knowledge as well as actual performance on key waste management subjects such as waste minimization, recycling and composting. To bridge such

differentials, post-hoc test suggests a sustained public education programme aimed at waste prevention.

Section 5.3.4 outlined a multivariate analysis of variance on the main barriers affecting sustainable MSW management in the City. Interaction effects between these dependent variables (barriers) and respondent groups were explored. Table 5.59 is a categorization of these barriers by order of importance (grand mean values). The most important barrier constraining sustainable waste management in Abuja is the very low level of public education on MSW management. On the other hand, the least important barrier by order of absolute mean values is the physico-chemical characteristics of waste samples from the City.

Section 5.3.5 outlined a multivariate Analysis of Variance on the main success factors affecting MSW management in Abuja. Interaction effects between these dependent variables (success factors) and respondent groups were also exhaustively explored. Table 5.65 categorizes these success factors by order of importance. The most important success factor affecting sustainable waste management in Abuja is the bourgeoning City population which has a huge potential for uptake of recycled products.

5.5: Recommendations

The following recommendations have been advanced as a panacea to overcome the barriers affecting sustainable MSW management in Abuja:

1. A comprehensive review of all legislative aspects relating to MSW management in the City should be undertaken with a view to harmonizing and aligning them to the objectives of the waste hierarchy, Strategic Environmental Assessment (SEA) and Integrated Waste Management (IWM) models.
2. There is an urgent need to draw up a ten year (medium term) waste strategy document in line with the expectations of Section 3(b) of FEPA Decree 59 of 1992. This plan should explicitly specify realistic targets for waste prevention, re-use, recycling, composting and energy generation.
3. Given the peculiar position of Abuja as a Federal Capital Territory, a rebalancing of the relationship between Abuja Environmental Protection Board, and other Federal agencies/organizations with oversight for waste management is required so to create new synergies. As part of this plan, a sustained public education programme on waste prevention and reuse targeted at schools, churches, community groups and third sector organizations should be designed.

4. Following the review of prevailing legal frameworks for waste management, a short term plan to train specialized manpower in critical areas of waste management should be initiated urgently. This programme can be implemented drawing on existing training capacities in the University of Abuja.
5. Further liberalization of waste management in Abuja is recommended by re-modelling it to be largely private sector driven. This will address to a large extent various financial and other operational barriers currently militating against efficiency in the sector as discussed in this chapter.

CHAPTER SIX

RESULTS FROM FOCUS GROUP ANALYSIS

6.0: Introduction

This chapter presents results from the focus group analysis carried out in September 2008. As stated in chapter three, the method was used primarily to validate and strengthen evidence and findings gathered from compositional analysis and questionnaire survey.

The chapter is organized in sections covering: (i) Introduction, (ii) barriers to sustainable MSW management, (iii) success factors affecting MSW management, (iv) strategy and policy prescriptions and (v) Conclusion and recommendations.

6.1: Parallel Focus Group Sessions

The objectives of the Focus Group Discussion (FGD) are as outlined previously. In line with the stated objectives, the FGD provided a relaxed and semi-formal atmosphere that encouraged participants to discuss exhaustively all aspects of MSW management in the City. To facilitate the discussion, a mixed approach of small group exercises and full group discussions was adopted. Such exercises were completed and collected after each session. Following an ice-breaker exercise and general introduction, a small group exercise was conducted to determine participants' levels of understanding of the subject. During the ice breaking discussions, participants were divided into four groups of four discussants (see Table 6.1 and figure 6.1) each to look at current municipal waste management practises in Abuja, the barriers and opportunities available and prescribe strategies that adapt global best practises to local conditions.

Table 6.1: Outline of participant groups

Group A	Group B	Group C	Group D
Abuja Environmental Protection Board Representative	Federal Capital Territory Administration Representative	Lecturer University of Nigeria Nsukka (UNN)	Abuja Environmental Protection Board (AEPB) Representative
Representative National Assembly	Representative Nigerian Institute of Hotel and Tourism	Representative Scavengers Association	MSW Consultant
Representative Scavengers Association	Representative Scavengers Association	Representative Households	Representative Households
Representative Households	Representative Abuja Municipal Area Council	Representative Waste Service Company	Representative Waste Service Company

Photo 6.1: Parallel focus groups in session (author's photograph).

6.2: Overview of Barriers Affecting Sustainable MSW Management in Abuja

Figure 6.1 is a diagrammatic representation of the main barriers affecting MSW management in the City as outlined by the FGD. Broadly, the barriers fall into four main categories: institutional/regulatory barriers, natural/physical barriers, operational barriers and socio-economic barriers.

6.2.1: Institutional and Legal Framework Supporting MSW Management in Abuja

The general position of the FGD was that MSW management in the City is still at a very rudimentary stage; as a result, gross inefficiencies are common. Table 6.2 is a summary of key legislative framework supporting solid waste management in Abuja. As reported by Adama (2007) and Imam *et al.*, (2008), the current institution and legal framework on which solid waste management in the City is resting is grossly inadequate. The FGD recommended a review of the existing legislative framework supporting MSW management in the City with a view to creating an effective strategy document based on global best practises.

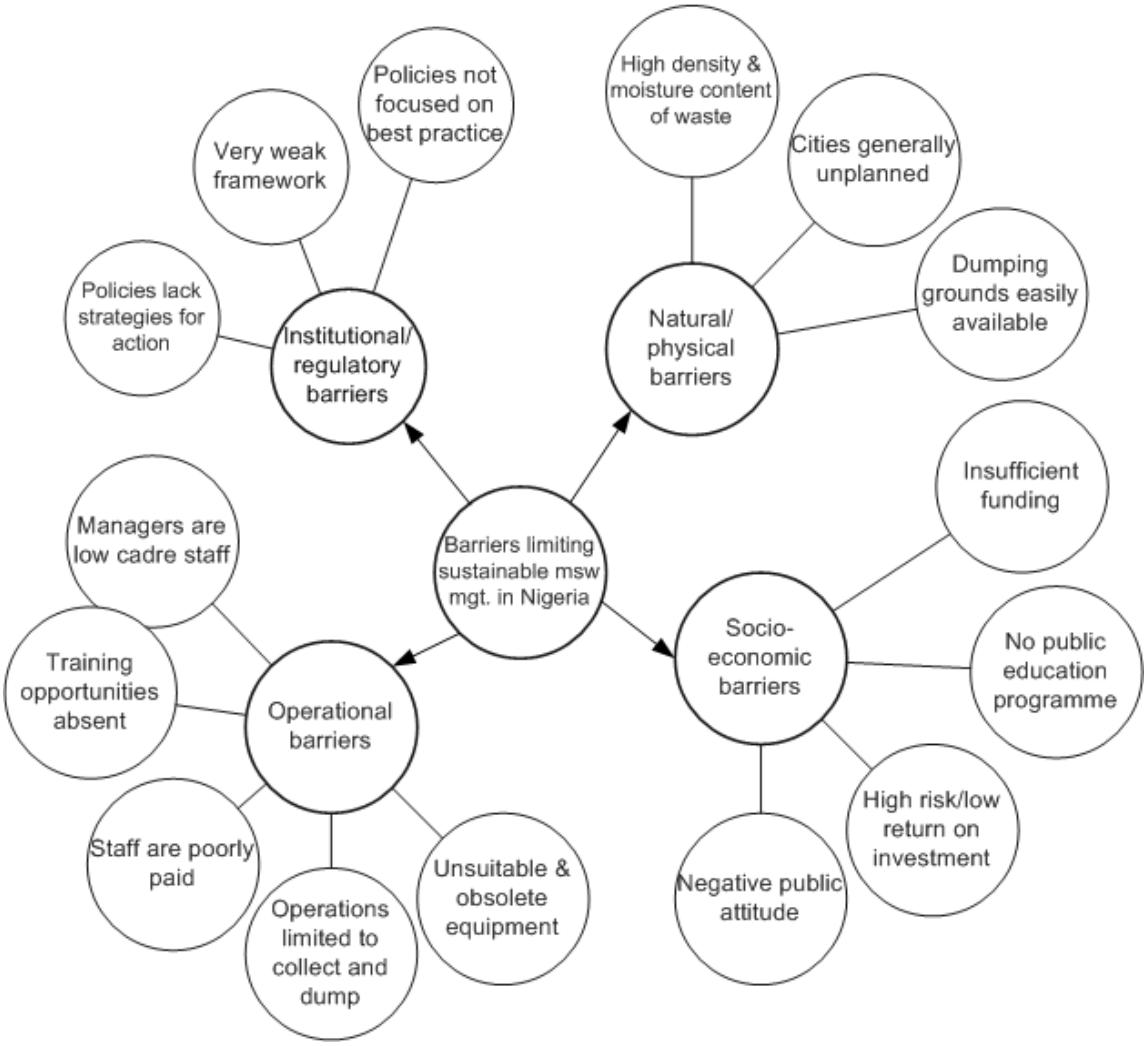

Figure 6.1: Barriers affecting sustainable MSW management in Abuja, Nigeria (Ezeah *et al.*, 2009a).

6.2.2: Natural/physical Barriers

Waste from tropical environments tends to be denser and higher in moisture content than samples from temperate regions of the world (Hernández-Berriel *et al.*, 2008). This presents serious operational difficulties as globally available waste management solutions are often not designed with such parameters in mind (Ezeah *et al.*, 2009a). Equally, the easy availability of dumping grounds in most parts of the country is an incentive for fly tipping and a barrier against more costly but sustainable disposal alternatives. Moreover, the poorly planned nature of Nigerian cities present added operational challenges such as access constraints to collection vehicles by narrow and unsurfaced streets.

Table 6.2: Key legislative aspects of MSW management applicable in Abuja

Legislation	Key elements related to waste management in Abuja
AEPB Decree 10 of 1997	Key objectives of this decree includes: Enforcement of all environmental legislation and abetment of all forms of environmental degradation and nuisance. Minimization of the impact of physical development on the ecosystem. Preservation, conservation and restoration to pre-impact status of all ecological processes essential for the preservation of biological diversity. Protection and improvement of air, water, land, forest, wildlife and ecological quality of the FCT. Municipal solid and liquid waste management services including provision of sewer services to properties.
FEPA Decree 58 of 1988 amended by Decree 59 of 1992	This legislation vests in FEPA overall responsibility for the protection and development of the environment, biodiversity conservation and sustainable development of Nigerian's natural resources in general and environmental technology, including initiation of policy related to environmental research and technology, among other functions. (S.4 Decree No. 59 1992). S.37 of the said Decree charges FEPA further with the responsibility of making regulations generally for the Purpose of the Act and in particular prescribe standards for: (a) Water quality; (b) Influent limitation; (c) Air quality; (d) Atmospheric protection; (e) Ozone protection; (f) Noise control; and (g) Control of hazardous substances and removal control methods.
The National Policy on the Environment	Launched by Government on 27th November 1989, this document describes guidelines and strategies for achieving the Policy Goal of Sustainable Development.
National guidelines and Standard For environmental pollution Control in Nigeria	This was launched on March 12th 1991 and represents the basic instrument for monitoring and controlling industrial and urban pollution.
National Effluence Limitation Regulations S.I.8 of 1991	This instrument makes it mandatory that industrial facilities install anti -pollution equipment, make provision for further effluent treatment, prescribe maximum limit of effluent parameters allowed for discharge, and spell out penalties for contravention.
Pollution Abatement in Industries facilities Generating Waste regulations S.I.9 of 1991	Restrictions are imposed hereunder on the release of toxic substances and requirement stipulated - Monitoring of pollution to ensure permissible limits are not exceeded: - Unusual and accidental discharges; - Contingency plans; - Generator's liabilities - Strategies of waste reduction and safety for workers.
Waste Management regulation S.I.15 of 1991	These regulate the collection, treatment and disposal of solid and hazardous waste from municipal and industrial sources and give the comprehensive list of chemicals and chemical waste by toxicity categories.

Table is based on: Etomi and Ebombe (2006).

6.2.3: Operational Barriers

Operational constraints are the bane of MSW management in Abuja. In many instances even basic materials for waste collection such as black bin bags and plastic receptacles are not available. Waste handling vehicles are limited to a few obsolete imports from more advanced countries of the world. Such equipment purchased at high costs are in turn easily scrapped because, usually, spare parts for their maintenance would normally have been off production lines, hence no longer available for purchase. Training opportunities in sustainable methods of MSW management are not easily available for operational staff. The effect is that most waste department in the City is manned by lower cadre staff. Such staffs have no place at decision making levels of the board. Ultimately therefore, waste issues are decided mostly by political expediency rather than sound science.

6.2.4: Socio-economic Barriers

Socio-economic realities in Abuja constitute a major block of barriers affecting sustainable MSW management. As most people struggle for economic survival, environmental considerations are often consigned to the background of individual priority lists. The very limited funding available to waste management authorities are not always applied judiciously. Sometimes, politically expedient but ad-hoc solutions are adopted at the expense of well articulated programmes aimed at waste minimization. Since the private sector is profit driven, present economic circumstances in Nigeria as a whole have tended to influence negatively the inflow of private capital for MSW management.

6.2.5: Aggregation of Whole Group Findings into a Strategy Tree

Following the ice-breaker exercise, a brief introduction to the next small group exercise was made, explaining that the purpose of the exercise are twofold – (a) To understand what issues constitute the main barriers to sustainable management of MSW in the various districts of Abuja (b) To focus on the barriers and offer best practicable environmental options for the AEPB to achieve greater efficiency in management. The four teams were given a pack of rose and star shaped sticker papers. The teams were requested to list identified barriers to sustainable waste management on the rose stickers and proffer possible solutions on the star stickers.

At the end of exercise 2 and following a short break, the whole group was brought together to discuss their findings (see photo 6. 2).

A representative of each team was then asked to present their findings as part of a strategy tree on the flip chart (see Photo 6.3).

Photo 6.2: Whole group discussion session (author's photographs).

Photo 6.3: Aggregation of FGD findings into a strategy tree (author's photographs).

6.3: Overview of Success Factors Affecting Sustainable MSW Management

Figure 6.2 below is a diagrammatic representation of the success factors affecting MSW management in the City as outlined by the FGD. As shown in the figure, these factors fall into five main categories: Character of the waste stream is suitable for composting, active informal sector engagement in MSW management can be further harnessed, large City population is potential

market for compost/recycled products, recent emergence of small and medium scale enterprises and low cost of labour.

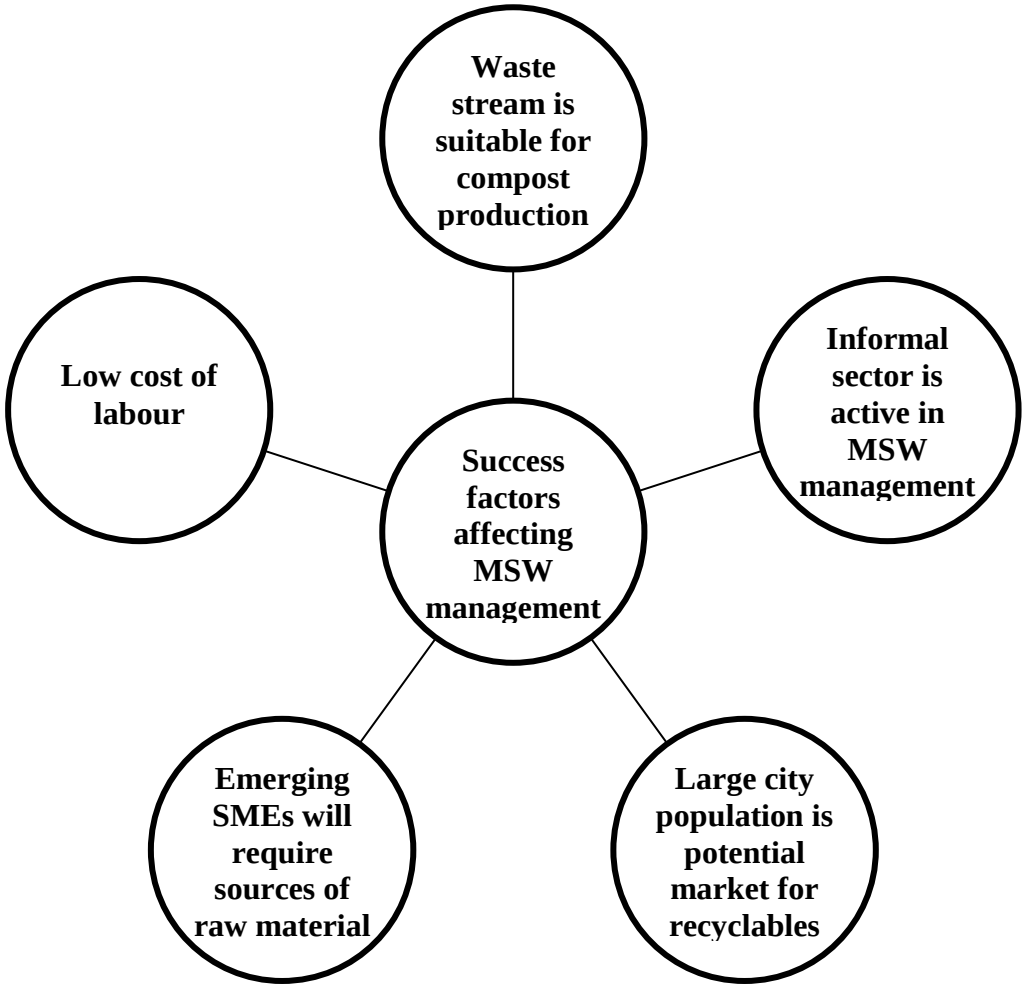

Figure 6.2: Success factors affecting sustainable MSW management in Abuja, Nigeria.

6.3.1: Character of Waste stream is suitable for Composting

The waste stream is high in organic content (60%). Moisture content is high as well. As a result of the basic character of waste in the City certain management options such as incineration are less favoured. It is however the opinion of the FGD that MSW samples from the City were suitable for compost production. The FGD therefore advocated the mainstreaming the informal sector in this direction by encouraging small scale, low technology compost production for urban farming.

6.3.2: The Informal Sector is already Active in MSW Recycling

The FGD estimated that about 11% of the waste stream in Abuja is composed of recyclable components. The AEPB cannot however recover value from this resource base since it has no formal recycling programme currently. As a consequence, materials re-use and recycling activities throughout the City are limited to household re-use and scavenging activities of the informal sector. Informal sector recycling is in two forms: (i) itinerant pickers, who go from house to house picking useful items from bins (this group consists mostly of unemployed young men with little basic education) (Agunwamba, 2003). The number of people engaged in this form of scavenging is not known as they operate on individual basis without any formal structure or association. (ii) The second group consists of scavengers that operate solely at the dump site, picking recyclable materials as they are dumped from disposal vehicles. This group is also largely made up of uneducated young men who commute daily from neighbouring slums and satellite towns to these dumpsites. This group tends to be more organized, as their activities are regulated by the leadership of their association. Collectively both groups account for the achievement of 3% recycling rate in the City presently.

6.3.3: Large City Population is Potential Market for Recycled Products

Abuja Federal Capital Territory, has an estimated population of 1.4 million people, of which 405,000 live and work within the municipality (National Population Commission, 2008). Total land area of the City is approximately 713 km^2 which is divided into six area councils i.e. Abuja Municipal, Abaji, Bwari, Gwagwalada Kuje and Kwali. It is the opinion of the FGD that this large and rapidly growing population is a potential market for recycled products, especially compost.

6.3.4: Emerging SMEs in Abuja Will Require Sustainable Sources of Raw Materials

Aside from a large and rapidly growing population, the City of Abuja has witnessed a steady growth in numbers of Small and Medium sized Enterprises (SMEs) in the recent past. Mainly these enterprises are engaged in construction, food processing, and a range of manufacturing activities (Ezeah *et al.*, 2009a). Increasing costs and stricter regulation on fresh raw materials exploitation could drive industries towards more sustainable alternatives, such as recycled products. The FGD saw this as potentially a major success factor affecting sustainable MSW management in the City.

6.3.5: Low cost of Labour

Over the past decade record numbers of people have migrated to Abuja from various parts of the country and beyond mainly for economic reasons. Net positive immigration has created a labour surplus especially amongst the youths in the City. Youth unemployment has generally tended to drive down cost of labour in the City. This trend is beneficial for labour intensive industries such as MSW management. Ultimately, low labour costs drives down production costs of recycled product thereby increasing market competitiveness.

6.4: Recommended Strategies for Sustainable MSW Management

Table 6.3 below summarizes identified barriers and success factors affecting municipal solid waste management in Abuja as represented on the strategy tree as well as prescribed strategies to achieve sustainable management.

Table 6.3: Barriers affecting sustainable MSW management in Abuja and strategies for overcoming barriers

Barriers to best practise	What can be done to overcome barriers
1. Low level public awareness on waste.	1. Strengthening of the enforcement organ of AEPB.
2. Little or no incentives to residents.	2. Sustained community mobilization/education programme.
3. Lack of awareness on the side of government.	3. Encouragement of small scale industries based on waste management.
4. Legal/policy framework on waste is weak.	4. Review of existing laws on waste.
5. Inadequate enforcement of existing laws.	5. Establishment of a sustainable solid waste management plan.
6. Few and obsolete equipment.	6. Initiate at source recycling programme for residents.
7. Public not willing to pay for AEPB services.	7. Government to provide the enabling environment for private investment.
8. Private sector investment is low.	8. Provision of adequate materials for waste collection, transfer and disposal.
9. Funding issues.	9. Strengthen public private participation.
10. Waste workers are poorly paid and poorly trained.	10. Encourage the informal sector.
11. Non recognition of role of informal sector in waste management.	11. AEPB to collaborate with other government departments such as AGIS.
12. Available funds are sometimes misused.	12. Prepayment strategy for waste services should be trial tested.
13. Frequent policy changes.	12. School based waste awareness programme.
14. Role conflict between government agencies.	13. Provide adequate funding to Waste management Authorities.
15. Recycling culture is low.	14. Greater political will on the part of government to undertake projects as planned.
16. General public apathy on environmental issues.	

6.5 Conclusion and Recommendations

Since Merton's pioneering work on group depth interview (Morgan, 1998), Focus Groups have become an increasingly useful research tool for applied social scientists. As distinguished from other group interviewing methods such as brainstorming or Delphi Groups, Focus Groups explore people's views and experiences on a set of specified issues. By employing group interaction, the technique produces data and insight on the subject that otherwise would have been hard to come by. Participants at the Abuja Focus Group Discussion were not only able to articulate their own views municipal solid waste management in the City but were also able to explain why they hold these views.

Overall the FGD session provided a convenient and cost effective method to assess the views of a representative cross section of stakeholders from the City on solid waste management. Table 6.3 is a summary of the main outcomes of the discussion. Given the small number of participants, the statistical significance of these findings is limited. As a complementary method however, these findings further validates those from waste composition analysis and questionnaire survey discussed in chapters four and five of this thesis. The following observations and recommendations encapsulate the essential findings from this method.

●Most of the people initially contacted to participate in the discussion were eager to attend due to a mixture of curiosity, desire to learn more and desire to contribute meaningfully to a more sustainable municipal solid waste management regime in the City.
●Though those initially contacted showed keen interest to participate in the discussion, about 10% of the invitees failed to turn up eventually for the discussion despite repeated reminders.
●It was the view of most of the participants that current solid waste management practises in the City are not sustainable as they are not underpinned by a robust scientific basis or clearly defined policy framework.
●To be able to achieve greater levels of efficiency, a City-wide, long term planning is necessary. This should be guided by measurable benchmark and timelines.
●Aspects of the planning should be tailored to address already identified barriers militating against sustainable solid waste management in the City.
●It was also noted that the level of public awareness on waste management in Abuja is very low. Practical ways of addressing this situation on the short to medium term as proffered by the group should include the timely commencement of a vigorous community based waste minimization awareness campaign at schools, churches and markets.

CHAPTER SEVEN

DISCUSSION

7.0: Introduction

Chapters Four to Six have attempted a detailed analysis of data collected in the course of this research with the aim of determining the stated objectives of this research. As a result of detailed analysis, best practise models for sustainable management of MSW in the case study area have been identified. Analysis has also highlighted other inferences that are discernible from the results. This chapter discusses further and aggregates the main findings from the research results with the aim of arriving at conclusions that will underpin strategies and recommendations prescribed in chapter eight.

7.1: Review

As earlier pointed out, MSW management in Abuja is rudimentary at best; as a result, gross inefficiencies are common (Ezeah *et al.*, 2009a). Drivers of the waste problem in the City include poverty, high population and urbanization growth rates as well as funding and infrastructural inadequacies (Walling *et al.*, 2004). At present, research and publications on MSW management in the City are relatively limited (Adama, 2007; Imam *et al.*, 2008; Roberts *et al.*, 2009; Ezeah *et al.*, 2009b). As a consequence, reliable data on MSW management in the City are restricted and difficult to obtain.

7.1.1: Peculiarities of MSW Sample Characteristics

This research (Figures 4.17 and 4.19) has established that the MSW stream in Abuja is composed of paper, cardboard, plastic film, dense plastic, glass, metals, non-ferrous metals, Putrescibles, textiles, miscellaneous combustibles, miscellaneous non-combustibles, WEEE, HHW and fine components. Compositional analysis of samples indicates that the main components during the dry season are putrescibles (47%), plastic film (13%), cardboard (9%), dense plastics (7%), paper (3%) and miscealleneous combustible materials (2%) . There is a noticeable difference in the character of the waste stream, however, in the wet season (Trankler *et al.*, 2005). For instance, while the putrescible component increased to approximately 50%, the quantity of plastic film marginally decreased to 11%. Other changes included, cardboard (8%), miscellaneous combustibles (5%) and dense plastics which reduced to (4%). The quantity of paper in the waste stream remained unchanged at 7%.

Unlike samples from temperate climatic conditions of Europe (Magrinho and Semiao, 2008), moisture content analysis of Abuja MSW samples (see Table 4.1) shows that the average moisture content of wet season samples is relatively higher at approximately 58.5%. The implication of this level of moisture is that samples are not easily amenable to disposal options such as incineration. However, they may be more suitable for composting and various other treatment options, such as biogas generation (Dollar, 2005; Lornage *et al.*, 2007).

Generally, the analysis of Abuja MSW samples seems to indicate that sample characteristics are typical of MSW samples from a tropical urban environment, i.e. high in biodegradable/organic fraction, high wet weight and moisture content and relatively low in industrial process fractions (Smith Korfmacher, 1997; Rushbrook and Pugh, 1999; John *et al.*, 2006; Sha'Ato *et al.*, 2007; Igoni *et al.*, 2007). This research finds from results of statistical comparison of sample characteristics over the dry and wet seasons as well as across sampling zones (see Tables 4.5 and 4.7, respectively) that there were no clear variation parttern.

7.1.2: Emerging Trends in MSW Management in Abuja

As stated in Section 6.2.3, the main legislative basis for MSW management in Abuja is the Abuja Environmental Protection Board Decree no. 10 of 1997. Other applicable legislation on waste management in the City includes FEPA Decree 58 of 1988 as amended by Decree 59 of 1992 and the National Policy on the Environment (1989). The volume of MSW generated within the City is currently estimated at about 67,000 tonnes annually (Figure 2.5). This figure is possibly well below actual volumes of waste generations since it is know that only about 50% of waste generated in the cities of developing countries, such as Abuja, actually find their way to designated dumpsites (Anomanyo, 2004; Ezeah *et al.*, 2009a). At an estimated annual growth rate of 3%, this figure is likely to double by the year 2025 (Figure 2.3).

Ezeah *et al.* (2009a) are of the view that up to 66.5% of the waste volume is composed of compostable biodegradable/organic fractions, generated mostly during the annual agricultural harvest period, between August and December. Actual quantities of waste generated per capita and per household in the City are unknown. Figures from studies in neighbouring cities with similar demographic and socio-economic characteristics such as Makurdi in North Central Nigeria (Appendix 2) and Accra, Ghana, are however put at 0.4 kg/head and waste density on a wet weight basis of 0.47 t/m^3 (Sha'Ato *et al.*, 2007). Apart from the compostable fraction, other recyclables in the waste stream include plastics, paper and metals.

Waste collection from most households and offices within the municipal area is on a door to door basis. At household level waste is stored in 240 L covered plastic receptacles or with black bin bags.

Many poorer households, especially those living in the satellite towns and informal settlements at the outer fringes of the City, use any available container such as baskets and open buckets for waste storage. Waste collection from households without any access constraints is carried out on a weekly basis, while collection from large organizations and commercial establishments is on daily basis. Equipment used for waste transfer includes side loaders, open tippers, pay loaders and roll- on -roll off trucks.

As has been earlier pointed out, the AEPB has no formal strategy or recycling programme for the City of Abuja, no material recovery facility exists either. Consequently, materials re-use and recycling activities throughout the municipality is limited to household re-use and scavenging activities of the urban poor. This research found that two main types of scavengers exist in the City; itinerant waste pickers, who go from house to house picking useful items from bins. This group consists mostly of unemployed young men with little basic education (Agunwamba, 2003; Kofoworola, 2007; Nzeadibe, 2009). The number of people engaged in this form of scavenging in the City is not known as they operate on individual basis without any co-operation or association. The second group consists also of those scavengers that operate solely at the dump site, picking recyclable materials as they are dumped from disposal vehicles. This also consists of uneducated young men who commute daily from neighbouring slums and satellite towns to these dumpsites. This group tends to be more organized, as their activities are regulated by the leadership of their association.

All said, the Abuja Environmental Protection Board, AEPB, has made some progress in an effort to bring greater sustainability in MSW management in the City lately. Recently the Board went into a public private participation agreement with some private waste services providers in this regard. The City has been divided into 13 waste management operational zones, each managed by an operator who is supervised by the AEPB.

7.1.3: Barriers Affecting Sustainable MSW Management in Abuja

This research has identified ten key barriers militating against sustainable management of MSW in the City of Abuja. These barriers (as earlier outlined in Sections 5.1.2 (Table 5.2) and 5.3.4 (Figure 5.7) of this thesis) include: (1) MSW management policies lack clear strategies for action. (2) Legal framework for MSW management is weak. (3) Waste management institutions in the City are still at their infancy and hence very weak. (4) Unplanned City aspects make waste collection difficult. (5) The character of MSW samples from the City is high in wet weight (density) and equally high in moisture content thereby creating additional operational management difficulties. (6) Availability of dumping grounds discourages expensive investment in alternative disposal methods. (7) Funding limitations. (8) Public education on MSW management is low. (9) Waste workers are poorly paid

and poorly trained. (10) Available operational equipments for MSW management are obsolete and insufficient.

These barriers constraining sustainable management of MSW in Abuja have been further grouped into four main categories: (1) Institutional/regulatory barriers (2) Natural/physical barriers (3) Operational/technical barriers (4) Socio-economic barriers (see Figure 6.1). How these barriers relate with each other and the extent to which they affect MSW management in Abuja have been explored in detail and the results of the analysis presented in Chapters Five and Six of this thesis. In this overall discussion section of the thesis an attempt is made to highlight and interpret the significance of some of the results with the objective of arriving at evidence based conclusions that will underpin recommended strategies for sustainable MSW management in the succeeding sections of this thesis.

7.1.3.1: Institutional/legislative barriers

As reported by Adama (2007) and Imam *et al*. (2008), the current institutional and legal framework supporting MSW management in the City of Abuja is grossly inadequate. A close evaluation indicates that the three pieces of legislation on which MSW management in Abuja is predicated (Abuja Environmental Protection Board Decree No. 10 of 1997; FEPA Decree 58 of 1988 as amended by Decree 59 of 1992 and the National Policy on the Environment, 1989) are all general purpose environmental legislations and not specific to MSW management. As such, they lack the level of detail that may be required of a legislative instrument that would have day-to-day application. These inadequacies in legislation are even more compounded by the fact that there are no clearly articulated strategies for the realization of the overall MSW management objectives of the City. The AEPB as the sole waste management institution in Abuja currently does not have the capaCity to enforce best practise MSW management in a sustainable manner. These weaknesses in legislation coupled with inherent institutional incapacities and unwillingness to enforce existing legislative provisions where applicable in a consistent and rigorous manner is a major impediment to achieving greater efficiencies in MSW management in the City.

7.1.3.2: Natural/Physical Barriers

Several studies on the character of MSW samples from tropical urban environments such as Abuja are of the opinion that they are high in biodegradable/organic fractions (Chung and Poon, 2001; Roberts *et al.*, 2009); tend to be denser in weight (Parizeau *et al.*, 2006; Igoni *et al.*, 2007) and higher in moisture content (Gawande *et al.*, 2003; Hernández-Berriel *et al.*, 2008) than samples from temperate regions of the world (Daskalopoulos *et al.*, 1998). This presents serious operational

difficulties as globally available waste management solutions often do not factor these parameters into their designs (Ezeah *et al.*, 2009a). The easy availability of dumping grounds in most parts of Nigeria is an incentive for fly tipping and a barrier against more costly but sustainable disposal alternatives. Moreover, the poorly planned nature of Nigerian cities present added operational challenges, such as access constraints to collection vehicles by narrow and unsurfaced streets (Agunwamba, 1998; Adama, 2007; Imam *et al.*, 2008).

7.1.3.3: Operational Barriers

Operational constraints also form a major block of barriers that affect MSW management in Abuja. Akoni (2007) noted that in many instances even basic materials for waste collection, such as black bin bags and plastic receptacles, are not available. Waste handling vehicles are limited to a few obsolete imports from more advanced countries of the world (Odunfa, 2007). Such equipment purchased at high costs are in turn easily scrapped because, usually, spare parts for their maintenance would normally have been off production lines, hence no longer available for purchase (Sakurai, 1990; Olowomeye, 1991; Purandare and Purandare, 2004). Training opportunities in sustainable methods of MSW management are not easily available for operational staff (NEEDS, 2004; Aye and Widjaya, 2006). The effect is that the AEPB, the sole MSW management department in the City is manned by lower cadre staff. Such staff have no place at decision making levels of the government, in this instance, The Ministry of the Federal Capital Territory (MFCT) and the Federal Capital Territory Administration. Ultimately, therefore, waste issues are decided mostly by political expediency rather than sound science (Rouse, 2006).

7.1.3.4: Socio-Economic Barriers

Results from this research point to the fact that the socio-economic realities in Abuja constitute the most important barriers affecting sustainable MSW management in the City currently (see Figure 5.4 of Section 5.3.4,). Though on aggregate terms the economic prospects of Abuja and Nigeria as a whole appear to be improving, recent studies still show a disproportionate percentage of the citizens living below poverty levels (The Economist, 2007; UNCED, 2007). As most people struggle for economic survival, environmental considerations are often consigned to the background of individual priority lists (Tonglet *et al.*, 2004; Timlett and Williams, 2008; Mbeng, 2009). The very limited funding available to waste management authorities are not always applied judiciously (Agbola, 2007). The direct consequence of economic and funding constraints is that public education on MSW management in the City is very low. Consequently, in many instances, politically expedient but ad-hoc solutions, such as “monthly sanitation/clean up programmes” and

"environmental task force teams" are adopted at the expense of well articulated programmes aimed at waste minimization (Zotos *et al.*, 2009; Nzeadibe, 2009; Ezeah *et al.*, 2009a). Additionally, since the private sector is profit driven, present economic circumstances in Nigeria as a whole have tended to negatively influence the inflow of private capital for MSW management (Miranda and Hale, 1997; Ogu, 2000; Manga *et al.*, 2008).

7.1.4: Success Factors Affecting Sustainable MSW Management in Abuja

This research identified four key success factors favouring sustainable management of MSW in the City of Abuja. These success factors as earlier outlined in Section 5.3.5 (Table 5.3) and Section 5.3.5 (Figure 5.8) of this thesis include: (1) A culture of informal sector recycling already exists in the City. (2) The waste stream is highly compostable. (3) Large City population offers potential markets for recycled products. (4) Recent emergence of small scale industries requiring recyclables as raw materials.

7.1.4.1: A Culture of Informal Sector Recycling Already Exists in Abuja

Estimates put the percentage recyclable components in the MSW samples from Abuja currently at between 11-30%. This quantity includes particularly such items as metals and cans and dense plastics (Ezeah *et al.*, 2008; Ezeah *et al.*, 2009a). A potential exist for about 70% of the waste stream composed entirely of biodegradable materials to be up taken for composting also (Mbeng, 2009). The AEPB cannot however recover value from this resource base since it has no formal recycling programme currently (Akoni, 2007). As a consequence, materials re-use and recycling activities throughout the City is limited to household re-use and scavenging activities of the informal sector (Agunwamba, 2003; Kofoworola, 2007; Imam *et al.*, 2008; Nzeadibe, 2009). As pointed out earlier, informal sector recycling in Abuja is in two forms:

Itinerant pickers, who go from house to house picking useful items from bins (this group consists mostly of unemployed young men with little basic education) (Agunwamba, 2003). The number of people engaged in this form of scavenging is not known as they operate on individual basis without any formal structure or association.

The second group consists of scavengers that operate solely at the dump site, picking recyclable materials as they are dumped from disposal vehicles. This group is also largely made up of uneducated young men who commute daily from neighbouring slums and satellite towns to these dumpsites. This group tends to be more organized, as their activities are regulated by the leadership of their association. Collectively both groups account for the achievement of about 3% of the recycling rate in the City in 2007/2008 (Odunfa, 2007; Ezeah *et al.*, 2009a)

7.1.4.2: Waste Stream is Highly Compostable

From Figures 4.17 and 4.19, approximately 70% of the MSW waste stream in Abuja is composed of biodegradable organic materials (Roberts *et al.*, 2009). As in many tropical environments, the waste stream is equally high in moisture content (see Table 4.1). Consequently, unit weight of the MSW sample is higher than samples from temperate climates (Asomani-Boateng and Haight, 1999; Blight *et al.*, 1999; Morrissey and Phillips, 2007; Magrinho and Semiao, 2008). As a result of the basic character of MSW in the City, certain management options such as incineration are less favoured (Daskalopolous, 1998a; Read, 2001; Malkow, 2004; Yongsheng *et al.*, 2005; Zotos *et al.*, 2009). The FGD held in the course of this research as well as relevant literature surveyed were of the opinion that MSW samples from Abuja were suitable for compost production because of its high organic and moisture content (Lewcock, 1995; Augenstein *et al.*, 1996; Gladding, 2002).

7.1.4.3: Large City Population offers Potential Market for Recycled Products

From Table 2.1, Abuja Federal Capital Territory, has an estimated population of 1.4 million people, of which 405,000 live and work within the municipality (National Population Commission, 2008). Total land area of the City is approximately 713 km^2. In recent years, Nigerian cities, including Abuja have witnessed large increases in population growth rates. Conservative estimates put the urban growth rate at about 5.51% per annum (Walling *et al.*, 2004). Some studies have put the annual growth of certain neighbourhoods in Abuja as high as 12.5% per annum (BBC, 2007). It is the opinion of the FGD that this large and rapidly growing population is a potential market for recycled products especially compost products for urban farming, giving the high cost of imported inorganic alternatives (Lewcock, 1995; Gladding, 2002; Wilson, 2007).

7.1.4.4: Recent Emergence of Small Scale Industries Requiring Recyclables as Raw Materials

Apart from a large and rapidly growing population, another important success factor impacting positively on sustainable MSW management in Abuja is the recent steady growth in numbers of Small and Medium Enterprises (SMEs) (Ezeah *et al.*, 2009a). Mainly, these enterprises are engaged in construction, food processing, and a range of manufacturing activities. As relevant governmental agencies in the City are empowered to commence stricter enforcement of environmental regulations, required globally for a low carbon economy, virgin raw materials costs are likely to rise (Beede and Bloom, 1995; UNEP, 2007). Increasing raw materials costs and stricter regulation on virgin raw materials exploitation would inevitably drive industries towards more sustainable alternatives such as recycled products (Ayalon *et al.*, 2001; Troschinetz and Mihelcic, 2009). The FGD conducted in the course of this research saw the recent emergence of SMEs in Abuja as

potentially a major success factor affecting sustainable MSW management in Abuja (see Figure 6.2).

7.2: Options Available for Management of MSW in Abuja

7.2.1: Waste Collection and Transfer

Results from analysis of MSW generation, collection and transfer in Abuja have been presented in Section 5.2.6.1 of this thesis. These results indicate that the more affluent neighbourhoods of Central Area, Maitama and Asokoro use mostly the 240 L standard bins for waste collection (Table 5.19). For instance, 56% of residents of Central Area district use 240 L plastic receptacles for waste collection as compared to Garki district with 39%. Only 3% of Maitama residents use open containers for waste collection. Open containers are mostly used by households in the satellite towns (14%), and poorer neighbourhoods of Garki (8%) and Wuse (8%). Apart from open containers, these districts also utilize mostly communal facilities for waste collection. By implication, affluent residents of Abuja are already adapting to the use of sustainable waste collection models. On the contrary, however, poorer households still rely on the traditional model of collecting waste with any available container (AMA, 2004; Ayomoh *et al.*, 2008). This system is usually unhygienic and therefore unsustainable (Roberts *et al.*, 2009). As Adama (2007) posits, a well articulated strategy to encourage all residents of the City to embrace sustainable waste collection options is urgently required to be put in place.

Results from Table 5.18 indicate that about 21% of respondents generated more than 240 L by volume of MSW per week. This might be indicative of a need to roll out larger sized bins in certain areas of the City, such as Asokoro (Table 5.21). At the same time about 26% of respondents said they generated less than 240 L by volume of MSW per week while another 16% of respondents said they generated more than a black bin. On the other hand, just over 9% of respondents said they generated less than a black bin bag of MSW per week. Some 26% of respondents said the volume of MSW they generated weekly varied widely. Overall, these results seem to indicate that there has been no study to match household MSW generation capacities with the sizes of collection receptacles issued. Such a study is critically required now so as to overcome issues of unused or inadequate capacities for waste collection.

Section 5.2.6.2 (Table 5.25) outlines five principal waste collection agents in Abuja: AEPB, private waste contractors, self, informal agents/scavengers and others. From this result about 33% of total MSW arising in the City is collected directly by AEPB. A situation where government is still

responsible for collecting over a third by volume of the City's MSW is still not sustainable. The global trend seems to be tending towards complete privatization of waste collection services, thereby freeing local waste authorities to carry out supervisory and oversight functions more efficiently (Bartone *et al.*, 1991; Clarke *et al.*, 1999; Ezeah, 2006; Phillips *et al.*, 2006).

7.2.2: Waste Disposal

Section 5.2.6.7 (Table 5.38) outlines four principal MSW disposal methods said to be in use in Abuja: sanitary landfills, open dumping, burning and incineration. This research found that over 60% of MSW generated in Abuja is officially disposed of at dumpsites as the City has no engineered landfills yet. The outstanding balance of MSW not collected for disposal at officially designated dumpsites are often buried or burned by waste generators. All three principal methods of MSW disposal in the City are neither hygienic nor environmentally sustainable. As Nissim *et al.*, (2005) recommended, there ought to be an immediate shift towards more sustainable MSW disposal options in the City. From Table 5.39, this research discovered that four reasons were identified as being responsible for open dumping in Abuja: (1) waste management facilities are unavailable or inadequate, (2) adequate information on sustainable disposal options are not available to residents, (3) legal deterrents by way of penalties are not enforced and (4) offenders are motivated to save costs.

7.2.3: Integrated MSW Management Option for Abuja

Currently the emphasis of MSW management in the City of Abuja is on waste collection and disposal in open dumps (see Table 5.38). This research proposes the replacement of the current "collect and dump" management model implemented by the AEPB with a comprehensive and integrated MSW management framework anchored on the waste hierarchy best practise model (Defra, 2008a). The integrated MSW management model considers the environmental and economic impacts any management option would have before incorporating same within the management framework. As discussed in Section 2.7 of this thesis, the best practise options for MSW management in Abuja in order of preference are: waste prevention, reuse, recycle/compost, energy recovery and disposal (see Figure 2.7). Having considered the character of the MSW sample in the City and the socio-economic context of Abuja, many technology intensive management options such as incineration may not be feasible in the City presently. This is particularly so as a result of manpower and financial constraints facing the City. Consequently, the following low cost and low technology management options have been adapted as key components of an integrated MSW management framework for Abuja.

7.2.3.1: Waste prevention

Results from questionnaire survey analysis (Section 5.2.4) have highlighted the very low levels of public education on MSW management in the City (see Tables 5.9, 5.10, 5.11). Low level education on waste management was discovered to be the greatest barrier to sustainable MSW management in the City (see Figure 5.7 and Table 5.59 of Section 5.3.4). To redress this situation, a radical public education programme aimed at waste prevention/minimization is urgently required as a key component of the City's waste management strategy (Read, 2001; Phillips *et al.*, 2004). This level of intervention has obvious resource implications (Rushbrook and Finnecy, 1988). Increasing resource allocation to the level of 30% of overall waste management budget, aimed at waste prevention will therefore constitute a critical component of this MSW management option. In this respect, the establishment of a City Waste Prevention Council (CWPC), to co-ordinate and promote waste prevention policies and programmes in partnership with existing organizations with waste management responsibility in the City such as the AEPB and other Federal Agencies. In this regard also, it will be required to develop a sustained multimedia waste prevention campaign and co-ordinate these with recycling and other waste management education efforts. The CWPC will be required to work with the Local Education Authority (LEA) to develop waste prevention curriculum modules to be taught in all primary and secondary schools in the City. Additionally, the CWPC will work towards (1) Establishing District Waste Prevention and Recycling Information Swap Centres in all districts of Abuja (2) Offer some incentives for businesses that institute qualifying prevention practises (3) Work towards establishment of a variable charging system for MSW services in the City based on amount of waste generated.

7.2.3.2: Recycling/Composting

The recycling/composting option is an important component of this integrated MSW management strategy which follows on the waste prevention component (Clarke *et al.*, 1999; Phillips *et al.*, 2006). As Rathi (2006) pointed out an effective recycling/composting programme is a key component of effective integrated MSW management programmes. Towards the achievement of this programme, a strategy document is required which will articulate a recycling/composting plan as well as specify targets to be met over the short as well as long term. Since the informal sector recycling culture is already well established in the City, as evidenced by Tables 5.25 and 5.37, the streamlining of the activities of this sector to complement a formal recycling/composting programme will also be necessary (Ezeah *et al.*, 2008).

Additionally, it is necessary to conduct a pilot collection programme substituting an extra recycling pickup for a refuse pickup, to relieve schools of storage burdens and providing incentives to

recycle. It is also necessary to incorporate a Recycling Business Unit within the AEPB structure to assist the City in devising ways to stimulate recycling industry investment and expansion. Along side these measures is a need to stimulate increased demand for recycled products within the City by encouraging residents to buy-recycled products.

7.2.3.3: Sanitary Landfilling

The final disposal point for residual wastes is landfill (Tchobanoglous *et al.*, 1993; Daskalopolous, 1998a). An engineered sanitary landfill constitutes the third side in the integrated MSW management plan advocated for the City of Abuja. A well managed sanitary landfill site will ensure that waste that cannot be managed other wise can be disposed of sustainably (Zotos *et al.*, 2009). In other to ensure that landfilling will be only used as the option of last resort, it is necessary to enshrine in the City's waste strategy document appropriate economic deterrents similar to the landfill tax in the United Kingdom.

7.3: Discussion of Research Aims

Aim 1: ***Analysis of municipal solid waste arising in Abuja, a major sub-Saharan African municipality representative of developing countries.***

Sections 2.2-2.4 of this thesis have attempted a review of current literature on MSW composition and management in four regional representative SSA countries, South Africa, Kenya, Ghana and Nigeria. Sections 2.6 and 2.7 reviewed extensively contemporary trends in MSW management in England, identifying best practises and suggesting how such practises can be adapted and transferred to developing socio-economic settings. Section 2.5 reviewed trends in MSW management in Abuja. It also compared synthesized historical data held by the AEPB in other to make medium term MSW generation projections. Sections 4.4-4.5 analysed the composition of the municipal solid waste stream collected from eight representative sampling zones carried out during the two main climatic seasons of the year. Based on findings from compositional analysis, questionnaire survey and focus group discussion, Section 7.2 outlined options available for MSW management in Abuja.

Aim 2: ***Analysis of the barriers and critical success factors necessary to achieve sustainability in the management of municipal solid waste in Abuja, a major municipality representative of cities of developing countries with a tropical climate***

Realization of this aim was hampered by the scant nature of available literature on the subject. Three methods were used for identification and analysis of barriers and success factors affecting MSW management in Abuja. These are: waste composition analysis, questionnaire survey and

focus group discussion. Focus group discussion (Section 6.2) yielded the greatest insight as to the nature of these barriers and success factors. A wide range of statistical analysis was carried out for factor assessment. ANOVA was used for scoring and calibrating the factors in order of their magnitude or importance.

Aim 3: ***To prescribe appropriate legislative and economic drivers to stimulate the uptake of critical performance indicators.***

Section 2.7.4 provided a critical review of the main drivers of best practise in UK's MSW management sector. Section 2.7.6 outlined key findings on the transfer of best practise drivers from the UK to developing socio-economic settings. Section 6.4 is a summary of recommendations from the FGD analysis to drive best practise in MSW management.

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.0: Summary

This research has empirically explored the composition of the MSW stream in Abuja, Nigeria. The research found that the MSW stream from the City is composed of fourteen key components in varying proportions during the two main climatic seasons of the year. The main components of dry season MSW samples could be summarized as: putrescibles (47%), plastic film (13%), cardboard (9%), paper (7%), dense plastic (7%), fine elements (5%), glass (4%) and metals and cans 3%. The remaining components of the sample constitute just about 5% by weight of sample. By inference, about 65% of the dry season waste sample is biodegradable, mostly comprising of high wet weight and high moisture content kitchen wastes. On the other hand, the main components of wet season MSW samples are: putrescibles (50%), plastic film (11%), cardboard (8%), paper (7%), dense plastic (4%), fine elements (4%), glass (2%) and metals (4%)%. The remaining components constitute about 11% of the entire weight of sample. This implies that about 70% of the wet season MSW sample is biodegradable with a relatively high moisture content of 58.5%. On the other hand, the outstanding 30% of the wet season sample comprises mostly of non- degradable but recyclable materials such as glass, metals and cans, non-ferrous metals and waste electrical and electonic equipments.

ANOVA tests of variance shows that only four material components, dense plastics, glass, miscellaneous combustibles and Household Hazardous Waste (HHW) varied significantly between the dry and wet seasons. In particular, there were more dense plastics in the sample in the dry season than wet season. Equally, there was more glass, in the waste stream in the dry season than the wet season. On the other hand, there were more miscellaneous combustibles and HHW in the waste stream in the wet season than the dry season. WEEE showed a weak variation between the two seasons. Paper, cardboard, plastic films, metals, non-ferrous metals, putrescibles, textiles, miscellaneous non-combustibles and fine elements showed no significant statistical variations over the two seasons.

ANOVA tests of variance also show that there were no significant variations in the means of material components both within and between the eight sampling zones. A possible explanation for this situation could be that consumption patterns amongst the residents of Abuja do not vary radically between areas and groups. ANOVA tests however, indicated that the means of four components, paper, cardboard, plastic films and putrescibles differed significantly when compared against different household income groups. The remaining ten components: dense plastics, glass, metals, non-ferrous metals, textiles, miscellaneous combustibles, miscellaneous non-combustibles,

WEEE, HHW and fine elements showed no significant statistical variations amongst these income groups.

The research equally analysed the barriers as well as success factors that affect sustainable MSW management in the City. Section 5.3.4 outlines results of a multivariate Analysis of Variance on the main barriers affecting sustainable MSW management in the City. Interaction effects between these dependent variables (barriers) and respondent groups were exhaustively explored. Table 5.59 is a categorization of these barriers by order of importance (grand mean values). From this table the most important barrier constraining sustainable waste management in Abuja is the very low level of public education on MSW management. On the other hand, the least important barrier by order of absolute mean values is the physico-chemical characteristics of waste samples from the City. The most important success factor affecting sustainable waste management in Abuja is the bourgeoning City population which has a huge potential for uptake of recycled products.

Multivariate Analysis of Variance indicates a strong, statistically significant variation between and within the three respondent groups in levels of knowledge as well as actual performance on key waste management subjects such as waste minimization, recycling and composting. To bridge such differentials, post-hoc test suggests a sustained public education programme aimed at waste prevention is required in the City.

The research discovered four principal MSW disposal routes in the City. These are sanitary landfills, open dumping, burning and incineration. Open dumping (62%) and burning (14%) were however, found to be the prevalent MSW disposal methods in Abuja.

The conclusion that can be drawn is that MSW management in Abuja is very rudimentary at best. Radical changes in current management strategy incorporating an integrated MSW management approach with emphasis in waste prevention via public education is required so as to bring MSW management in Abuja in line with globally accepted best practises.

8.1: Conclusions

The following conclusions have been arrived at from this investigation:

- A geo-demographic classification of the case study area (Figure 5.6) shows that Garki District has the highest concentration of hard pressed and moderate means (poor) neighbourhoods (8%). Garki and Wuse districts account for the largest concentrations of mid income neighbourhoods (72% and 66%, respectively) while Maitama and Asokoro districts largely consist of wealthy neighbourhoods.

- Generally, climatic conditions throughout the study period were stable and typical for the region (see Appendix 3 a-e). The effect of seasonal variations on the character of MSW samples from the City was not found to be statistically significant (Table 4.5).

- Between 65-70% of MSW samples from Abuja are biodegradable, mostly comprising of high wet weight and high moisture content kitchen wastes. Between 11-30% of MSW samples from the City comprised mostly of non- degradable but recyclable materials such as glass, metals, non-ferrous metals and waste electrical and electonic equipments (see Table 4.4).

- Proximate analysis of samples revealed relatively high moisture content of 58.5% (see Table 4.1). The implication of this level of moisture is that samples are not suitable for incineration, but are suitable for composting and other mechanical and biological management options.

- Statistical tests revealed that there were no significant variations in the character of samples both within and between the sampling zones (see Table 4.7).

- Analysis of waste generation and collection showed that affluent households tend to generate more waste than poorer households (see Table 5.21).

- Cost of waste services was not proportional to amount of waste generated, implying that in real terms, wealthier residents tended to pay less for waste services than poorer residents in the City (see Tables 5.27).

- Multivariate statistical analysis indicates a strong, statistically significant variation between and within the three respondent groups in their levels of knowledge as well as self reported performance on key waste management subjects such as waste minimization, recycling and composting (see Table 5.48).

- The main barriers to sustainable MSW management in the City are low public awareness/education on MSW management, obsolete and insufficient equipment and funding limitations. On the other hand, the least important barrier constraining

sustainable MSW management in the City was perceived to be the physico-chemical characteristics of waste samples (see Figure 5.7 and Table 5.59).

- The most important success factor affecting sustainable MSW management in Abuja was the bourgeoning City population which has a huge potential for uptake of recycled products (see Figure 5.8 and Table 5.65).

In summary, the factors affecting MSW management in Abuja are typical of other tropical urban environments. Fundamental shifts in waste education are necessary to bring about sustainable management.

8.2: Recommendations

As stated earlier, MSW management in Abuja is still in its infancy. A plethora of barriers presently constrain sustainable management (Walling *et al.*, 2004). Given these limitations, this research has provided new directions on what could be done to bring about greater efficiency and sustainability. The following recommendations have thus been put forward as strategic and policy initiatives in this regard:

8.2.1: Legislative, Institutional and Economic Recommendations

1. The legislative basis for MSW management in Abuja and indeed the whole of Nigeria is very weak. This research therefore recommends a comprehensive review of all legislative aspects relating to MSW management in the City with a view to strengthening, harmonizing and aligning them to the objectives of the waste hierarchy, Strategic Environmental Assessment (SEA) and Integrated Waste Management (IWM) models.
2. Much of the operational challenges constraining sustainable MSW management in the City are traceable to the absence of a comprehensive strategy document for sustainable waste management in Abuja. There is therefore an urgent need to draw up a ten year (medium term) waste strategy document in line with the expectations of Section 3(b) of FEPA Decree 59 of 1992. This plan should explicitly specify realistic targets for waste prevention, re-use, recycling and composting.
3. Though government has recognized the need for the private sector to a play greater role in the delivery of waste services in the City, it has not been able to attract capable private companies with global experience because of perceived negative influence of government on the sector. To overcome this situation, further liberalization of waste management in

Abuja is recommended. This will require re-modelling of MSW management in the City to be largely private sector driven. This will in turn, address to a large extent various economic and other operational barriers currently impeding efficiency.

4. A detailed waste infrastructure development master plan adapted to the broad objectives of the Abuja master plan is required to guide future developments in waste infrastructure.
5. Given the unique position of Abuja as a Federal Capital Territory, a rebalancing of the relationship between AEPB, and other Federal agencies/organizations with oversight for waste management is required so to create new synergies.
6. There is a need to design a sustained public education programme on waste prevention and reuse targeted at schools, churches, community groups and third sector organizations in the City.
7. A short term plan to train specialized manpower in critical areas of waste management should be initiated urgently. This programme can be implemented drawing on existing training capacities in the University of Abuja.

8.2.2: Operational Recommendations

1. As a short term measure, there is a need to upgrade existing facilities at major open dump sites in the City by providing access roads, security fencing, temporary shelters and other utilities to make for a better environment. Following this all other illegal dumpsites in the City should be closed.
2. The AEPB as presently constituted requires further strengthening in terms of man-power, training and financing to be able to perform its function more effectively (see Table 6.3). In particular, the AEPB waste management division should be strengthened so as to be able to monitor, regulate and enforce applicable waste related legislation in the City more effectively.
3. This research recognizes that the informal sector is currently responsible for collection of 10% of MSW arising in Abuja (see Table 5.25) while recycling and disposing 3% and 7%, respectively (see Table 5.37). Their current operations are however mostly unco-ordinated and hampered by several barriers. To enhance their effectiveness, there is a need to streamline their operations and support them by way of incentives and training in sustainable recycling and composting as a business.
4. There is presently a dearth of timely and accurate data in waste management in Abuja as is the case in many SSA cities. To overcome this situation, this research recommends the upgrading of the laboratory unit of the AEPB to a fully fledged waste management research

institute with responsibility for advancing waste research and the management of a central waste data bank in the FCT.

8.3: **Recommendations for Further Research**

Based on the findings of this research and in view of certain limitations that constrained it such as time and resource as earlier highlighted, a number of recommendations have been put forward below to provide some direction for future research endeavour in this domain:

1. This research focused on the analysis of physical composition of MSW samples from Abuja. To fully understand the character of the Abuja waste stream, further chemical characterization including proximate and ultimate analysis is required. Future research in this genre must endeavour to collect data from a bigger sample to increase the precision of the analysis and to enable firmer conclusions to be drawn.

2. As a result of time and other limitation, this study was limited to the five districts of Abuja Municipality. To further increase the applicability of the results and findings, it is recommended that a second study be carried out to cover the entire six area councils of the FCT. This phase will provide the opportunity for the study of MSW management in the more rural districts of the FCT which are more characteristics of many less developed municipalities of Nigeria.

3. This research has looked at seasonal variation in MSW composition in the case study area in the context of climatic dynamics. To be able to fully understand the effect of seasonality on MSW composition, further studies on the impact of cultural and religious seasonality on waste composition is recommended.

4. The informal sector recycling culture is an important success factor that could enhance sustainable MSW management in the City. To be able to mainstream this sector into the overall MSW management strategy of the City, there is a need to carry out an audit of the entire population engaged in informal sector recycling both in the itinerant and dump site based forms.

5. As indicated in Section 3.3.1, the research context was limited to households in Abuja Municipal Area Council, (AMAC). It is entirely plausible that there may be significant differences in the findings if this study is replicated in other SSA municipalities. It will be

interesting and useful for benchmarking purposes to find out if differences do exist. It is therefore recommended that this study is replicated in other Cities of Sub Saharan Africa to allow for comparative analysis to be undertaken.

6. There is an urgent need for a study to calculate actual MSW arising in the City and to match household MSW generation capacities with the needs for essential MSW management consumables. Such a study is critically required now so as to overcome issues of unused or inadequate capacities in MSW management.

REFERENCES

Aboyade, A. (2004) *The potential for climate change mitigation in the Nigerian solid waste disposal sector: A case study of Lagos-Nigeria.* MSc. Thesis, Lund University, Sweden.

Achankeng, E. (2003) Globalization, urbanization and municipal solid waste management in Africa. *In* African Studies Association of Australasia and the Pacific (2003) 26th Annual *Conference Proceedings: Africa on a global stage, University of Adelaide, Australia* [online]. Available: http://www.afsaap.org.au/Conferences/2003/Achankeng.pdf <accessed 12 April 2007>.

Adama, O. (2007) *Governing from above: Solid waste management in Nigeria's new capital city of Abuja*. Ph.D. Thesis, Stockholm University, Sweden.

Adelagan, J. A. (2004) The history of environmental policy and pollution of water sources in Nigeria (1960-2004). *Department of Civil Engineering University of Ibadan, Nigeria* [online]. Available: http://userpage.fu-berlin.de/ffu/akumwelt/bc2004/download/adelegan_f.pdf.

Adeoti, T. (2001) *Technology investment in pollution control in sub Saharan Africa: the case of the Nigerian manufacturing industry*. PhD Thesis, United Nations University Maastricht, The Netherlands.

African Development Bank, AfDB (2002) *Study on solid waste management options for Africa*. AfDB Sustainable Development and Poverty Reduction Unit, Abidjan, Cote d'Ivoire.

Afon, A. O. (2007) Informal sector initiative in the primary sub-system of urban solid waste management in Lagos, Nigeria. *Habitat International*, **31**(2), pp.193-204.

Afroz, R., Hanaki, K. & Hasegawa-Kurisu, K. (2009) Willingness to pay for waste management improvement in Dhaka City, Bangladesh. *Journal of Environmental Management*, **90**(1), pp.492-503.

Agbola, T. (2007) Urbanization, slum development and security of tenure: The challenge of meeting Millennium Development Goal (MDG) 7 in metropolitan Lagos, Nigeria. *Paper presented to the PRIPODE Workshop on Urban Population, Development and Environmental Dynamics in Developing Countries, Nairobi Kenya*.

Agunwamba, J. C. (1998) Solid waste management in Nigeria: Problems and issues. *Environmental Management*, **22**(6), pp.849-856.

Agunwamba, J. C. (2003) Analysis of scavengers' activities and recycling in some cities of Nigeria. *Environmental Management*, **32**(1), pp.116-127.

Ahmed, S. A. and Ali, M. (2004) Partnerships for solid waste management in developing countries: linking theories to realities. *Habitat International*, **28**(3), pp.467-479.

Ahorttor, W. & Asiamah, G. D. O. (2000) Environmental enforcement and compliance in Ghana. *In* the proceedings of the 5th International Conference on Environmental Compliance and Enforcement, Workshop 3G, October 2000, Vol 1 &2, Washington, DC, USA.

Akinbode, O. M., Eludoyin, A. O. & Fashae, O. A. (2008) Temperature and relative humidity distributions in a medium-size administrative town in southwest Nigeria. *Journal of Environmental Management*, **87**(1), pp.95-105.

Akoni, J. (2007) *Municipal solid waste management in Abuja.* Internal Departmental Evaluation Paper. Waste Management Department, Abuja Environmental Protection Board, Ministry of the Federal Capital, Abuja, Nigeria.

Akpofure, E. A. & Echefu, N. (2001) *Environmental impact assessment in Nigeria: regulatory background and procedural framework.* UNEP EIA training resource manual, case study from developing countries. United Nations Environment Programme, Nairobi, Kenya.

Accra Metropolitan Authority (2004) Report on Municipal waste management operations in Accra city. *Accra Metropolitan Authority (AMA).*

Ankrah, N. A. (2007) *An Investigation into the impact of culture on construction project performance*. Ph.D Thesis, University of Wolverhampton.

Anomanyo, A. D. (2004) *Integration of municipal solid waste management in Accra (Ghana): Bioreactor treatment technology as an integral part of the management process*. MSc. Thesis, Lund University Helsingborg, Sweden

Asomani-Boateng, R. & Haight, M. (1999) Reusing organic solid waste in urban farming in African cities - A challenge for urban planners. *Third World Planning Review*, **21**(4), pp.411-428.

Audit Commission (1997) *Waste matters, good practice in waste management*. Audit Commission for Local Authorities and the National Health Service in England and Wales. London, United Kingdom: Management Handbooks, ISBN/RCN 1862400482.

Augenstein, D., Wise, D. L., Dat, N. X. & Khien, N. D. (1996) Composting of municipal solid waste and sewage sludge: Potential for fuel gas production in a developing country. *Resources, Conservation and Recycling*, **16**(1-4), pp.265-279.

Ayalon, O., Avnimelech, Y. & Shechter, M. (2001) Solid waste treatment as a high-priority and low-cost alternative for greenhouse gas mitigation. *Environmental Management*, **27**(5), pp.697-704.

Aye, L. & Widjaya, E. R. (2006) Environmental and economic analyses of waste disposal options for traditional markets in Indonesia. *Waste Management*, **26**(10), pp.1180-1191.

Ayomoh, M. K. O., Oke, S. A., Adedeji, W. O. & Charles-Owaba, O. E. (2008) An approach to tackling the environmental and health impacts of municipal solid waste disposal in developing countries. *Journal of Environmental Management*, **88**(1), pp.108-114.

Babbie, E. R. (1990) *Survey research methods*. Belmont, California, USA: Wadsworth Publishing Co.

Baker, M. J. (2003) Data collection - Questionnaire design - *The Marketing Review*, **3**, pp.343-370.

Balch, G. I. & Mertens, D. M. (1999) Focus group design and group dynamics: Lessons from deaf and hard hearing participants. *The American Journal of evaluation*, **20**(2), pp.265-277.

Barton, J. R., Issaias, I. & Stentiford, E. I. (2008) Carbon - Making the right choice for waste management in developing countries. *Waste Management*, **28**(4), pp.690-698.

Bartone, C. R., Leite, L., Triche, T. & Schertenleib, R. (1991) Private-Sector Participation in Municipal Solid-Waste Service - Experiences in Latin-America. *Waste Management & Research*, **9**(6), pp.495-509.

British Broadcasting Cooperation, BBC (2007) *Life of poverty in Abuja's wealth* [online]. London: BBC News website [Cited Tuesday 13th February, 2007]. <http://news.bbc.co.uk/1/hi/world/africa>.

Beede, D. N. & Bloom, D. E. (1995) The Economics of municipal solid waste. *World Bank Research Observer*, **10**(2), pp.113-150.

Benneh, G., Songsore, J., Nabila, J. S., Amuzu, A. T., Tutu, K. A., Yangyuoru, Y. & McGranahan, G. (1993) Environmental problems and the urban household in the Greater Accra Metropolitan Area, Accra-Ghana. *Stockholm Environment Institute, Stockholm, Sweden*

Black, C., Akintiye, A. & Fitzgerald, E. (2000) An analysis of success factors and benefits of partnering in construction. *International Journal of Project Management*, **18**, pp.423-434.

Blight, G. E., Fourie, A. B., Shamrock, J., Mbande, C. & Morris, J. W. F. (1999) The effect of waste composition on leachate and gas quality: a study in South Africa. *Waste Management & Research*, **17**(2), pp.124-140.

Boadi, K. O. & Kuitunen, M. (2003) Municipal solid waste management in the Accra Metropolitan Area. *The Environmentalist*, **23**(3), pp. 211-218(218).

Brinberg, D. & McGrath, J. E. (1985) *Validity and the research process*, Beverly Hills; London, United Kingdom: Sage Publications.

Brunner, P. H. & Ernst, W. R. (1986) Alternative methods for the analysis of municipal solid waste. *Waste Management & Research*, **4**(2), pp.147-160.

Bryman, A. (1988) *Quantity and quality in social research*. London, United Kingdom: Sage Publications.

Buenrostro, O., Bocco, G. & Bernache, G. (2001) Urban solid waste generation and disposal in Mexico: a case study. *Waste Management & Research*, **19**(2), pp.169-176.

Burnley, S. J. (2007) A review of municipal solid waste composition in the United Kingdom. *Waste Management*, **27**(10), pp.1274-1285.

Chokor, B. A. (1993) Government Policy and environmental protection in the developing world: the example of Nigeria. *Environmental Management*, **17**(1).

Christopherson, R. W. (2005) Geosystems: *An Introduction to Physical Geography*. Prentice Hall. Upper Saddle River, NJ, USA.

Chung, S.S. (2008) Using plastic bag waste to assess the reliability of self-reported waste disposal data. *Waste Management*, **28**(12), pp.2574-2584.

Chung, S. S. & Poon, C. S. (2001) Characterization of municipal solid waste and its recyclable contents of Guangzhou. *Waste Management Research*, **19**, pp.473-485.

Clarke, M. J., Read, A. D. & Phillips, P. S. (1999) Integrated waste management planning and decision-making in New York City. *Resources, Conservation and Recycling*, **26**(2), pp.125-141.

Clarkson, P. A., Adams, J. C. & Phillips, P. S. (2002) Third generation waste minimisation clubs: a case study of low cost clubs from Northamptonshire, UK. *Resources, Conservation and Recycling*, **36**(2), pp.107-134.

Coggins, C. (2001) Waste prevention -- an issue of shared responsibility for UK producers and consumers: policy options and measurement. *Resources, Conservation and Recycling*, **32**(3-4), pp.181-190.

Cointreau, S. (1982) *Environmental management of urban solid wastes in developing countries: a project guide*. Urban Development Technical Paper Number 5, World Bank, Washington DC.

Coker, A., Sangodoyin, A., Sridhar, M., Booth, C., Olomolaiye, P. & Hammond, F. (2009) Medical waste management in Ibadan, Nigeria: Obstacles and prospects. *Waste Management*, **29**(2), pp.804-811.

Collingridge, D. (1982) *Critical decision making: A new theory of social choice*, London, United Kingdom: Frances Printers.

Contreras, F., Ishii, S. Hanaki, K. (2006) Drivers in current and future municipal solid waste management systems: cases in Yokohama and Boston. *Department of Urban Engineering, University of Tokyo, Japan*.

Cox, D., Fafchamps, M., Schultz, T. P. John, A. S. (2007) Chapter 58 Extended Family and Kinship Networks: Economic Insights and Evolutionary Directions. *In Handbook of Development Economics.* Elsevier, pp.3711-3784.

Creswell, J. W. (2003) *Research design: qualitative, quantitative, and mixed method approaches*. Thousand Oaks, Calif., USA: Sage Publications.

Dahlén, L. & Lagerkvist, A. (2008) Methods for household waste composition studies. *Waste Management*, **28**(7), pp.1100-1112.

Daskalopolous, E. (1998a) An integrated approach to municipal solid waste management. *Resources Conservation and Recycling*, **24**(1), pp.33-50.

Daskalopoulos, E., Badr, O. & Probert, S. D. (1998b) Municipal solid waste: a prediction methodology for the generation rate and composition in the European Union countries and the United States of America. *Resources, Conservation and Recycling*, **24**(2), pp.155-166.

Dayal, G., Yadav, A., Singh, R. P. & Upadhyay, R. (1993) Impact of climatic conditions and socio-economic status on solid waste characteristics: a case study. *The Science of The Total Environment*, **136**(1-2), pp.143-153.

De Vaus, D. A. (2007) *Surveys in Social Research*, 5th edition., Routledge, London.

Department for Environment Food and Rural Affairs, Defra (2005) *Calderdale waste analysis*, report prepared for Calderdale Borough Council, Halifax, UK by Community Recycling Services, pp1-18.

Department for Environment Food and Rural Affairs, Defra (2007) *Waste Strategy for England* [online]. London, United Kingdom: [cited 21 November, 2008] <http://www.defra.gov.uk/defrasearch>.

Department for Environment Food and Rural Affairs, Defra (2008a) *Recycling and waste* [online]. London, United Kingdom: [cited 14 January 2008] <http://www.defra.gov.uk/environment/waste/index.htm>.

Department for Environment Food and Rural Affairs, Defra (2008b) *Incineration of municipal solid waste in the UK* [online]. London, United Kingdom: [cited 8 January 2009]. <http://www.defra.gov.uk/environment/waste>.

Department for Environment Food and Rural Affairs, Defra (2010) *Recycling and waste* [online]. London, United Kingdom: [cited 22 March 2010] <http://www.defra.gov.uk/environment/waste/index.htm>.

Dehri, I. & Erbil, M. (2000) The effect of relative humidity on the atmospheric corrosion of defective organic coating materials: an EIS study with a new approach. *Corrosion Science*, **42**(6), pp.969-978.

Denzin, A. L. Lincoln, Y. S. (1994) (eds.) *Handbook of Qualitative Research*. Thousand Oaks, California, USA: Sage Publications.

Department of the Environment, DoE (1990) *Environmental Protection Act*. London UK, HMSO.

Department of the Environment, DoE (1995) *Making Waste Work: A strategy for sustainable waste management in England and Wales*. London, UK, HMSO.

Department of the Environment Transport and Regions, DETR (2000) *A waste strategy for England and Wales*. London, UK.

Dollar, L. (2005) Moisture retention of municipal solid waste mixed with sewage sludge and ash in a semi-arid climate. *Waste Management & Research*, **23**(3), pp.209-219.

Edoho, F. & Dibie, R. (2000) Executing environmental policy and waste management in Ghana and Nigeria. *Journal of Sustainable Development in Africa*, **2**(2).

European Environment Agency, EEA (2003) *Assessment of Information related to waste and material flows- a catalogue of methods and tools* [online]. Copenhagen, Denmark [cited 15 September, 2007]. <http://www.eea.europa.eu>.

Environmental Protection Agency, EPA (1994) Characterization of municipal solid waste in the United States [online]. [cited 12 March, 2008]. <http://www.epa.gov/fedrgstr>

Etomi, G. & Ebombe, S. (2006) Environmental legislation changes in Nigeria: what impact on foreign investment? *George Etomi & Partners*, Lagos, Nigeria [online]. [cited 18 January, 2008]. <http://www.geplaw.com/environmental_law.htm>.

EU Landfill Directive (1999) *Council Directive on Landfill of Waste*. Official journal of the European Communities [online]. [cited 28 August 2008]. <http://eur-lex.europa.eu>.

Europa (2006) *Framework Directive on Waste (91/156/EEC)* [online]. [cited 12 January, 2008]. <http://eur-lex.europa.eu>.

Europa (2008) *Environment in the EU27: MSW recycling/composting rates in 2008* [online]. [cited 19 March, 2010].<http://epp.eurostat.ec.europa.eu/cache>.

Ezeah, C. (2006) *Design of a municipal solid waste management strategy for the City of Wolverhampton.* MSc. Thesis, University of Wolverhampton.

Ezeah, C., Roberts, C. L., Watkin, G., Philips, P. S. & Odunfa, A. (2008) Abuja: From Waste to Wealth. *In* the Proceedings of The Resource Efficiency Knowledge Transfer Network and WARMNET first combined conference for Postgraduate & New researchers and Industry, 30th June- 1st July, 2008, University of Nottingham, UK, vol.1 (Issue 1), p.39.

Ezeah, C., Roberts, C. L., Watkin, G. D, Philips, P. S. & Odunfa, A. (2009a) Analysis of barriers affecting the adoption of a sustainable municipal solid waste management system in Nigeria. *In* the proceedings of the 24th International Conference on Solid Waste Technology and Management, 12 - 15 March, 2009. Widener University, Philadelphia, P.A, USA, pp. 1556-1564.

Ezeah, C., Roberts, C. L., Phillips, P. S., Mbeng, L. O. & Nzeadibe, T. C. (2009b) Evaluation of public health impacts of waste scavenging in Abuja Nigeria, using Q-methodology. *In* the Proceedings of International Solid Waste Association ISWA World Congress, 12-15 October 2009, Lisbon, Portugal.

Federal Government of Nigeria (1988), *Federal Environmental Protection Agency (FEPA) decree No 58*. Federal Ministry of Information and Culture, Lagos.

Field, A. (2000) *Discovering Statistics: Using SPSS for Windows*. London. Sage Publications Ltd.

Gawande, N. A., Reinhart, D. R., Thomas, P. A., McCreanor, P. T. & Townsend, T. G. (2003) Municipal solid waste *in situ* moisture content measurement using an electrical resistance sensor. *Waste Management*, **23**(7), pp.667-674.

Gladding, T. (2002) Waste composting for urban and peri-urban agriculture: Closing the rural-urban nutrient cycle in Sub-Saharan Africa: Ed. P. Drechsel and D. Kunze, CABI Publishing, Wallingford, UK, 2001, 256 pp. ISBN 0 85199 548 9, Hardback. *Waste Management*, **22**(7), pp.837-838.

Grodzinska-Jurczak, M. (2003) The relation between education, knowledge and action for better waste management in Poland. *Waste Management & Research*, **21**(1), pp.2-18.

Halla, F. & Majani, B. (1999) Innovative ways for solid waste management in Dar-es-Salaam: Toward stakeholder partnerships. *Habitat International*, **23**(3), pp.351-361.

Henry, R. K., Zhao, Y. S. & Dong, J. (2006) Municipal solid waste management challenges in developing countries - Kenyan case study. *Waste Management*, **26**(1), pp.92-100.

Hernández-Berriel, M. C., Márquez-Benavides, L., González-Pérez, D. J. & Buenrostro-Delgado, O. (2008) The effect of moisture regimes on the anaerobic degradation of municipal solid waste from Metepec (México). *Waste Management*, **28** (Supplement 1), pp.S14-S20.

Husaini, I. G., Garg, A., Kim, K. H., Merchant, J., Pollard, S. J. T. & Smith, R. (2007) European household waste management schemes: Their effectiveness and applicability in England. *Resources, Conservation and Recycling*, **51**(1), pp.248-263.

Ibiebele, D. D. (1986) Rapid method for estimating solid wastes generation rate in developing countries. *Waste Management & Research*, **4**(4), pp.361-365.

Igoni, A. H., Ayotamuno, M. J., Ogaji, S. O. T. & Probert, S. D. (2007) Municipal solid-waste in Port Harcourt, Nigeria. *Applied Energy*, **84**(6), pp.664-670.

Imam, A., Mohammed, B., Wilson, D. C. & Cheeseman, C. R. (2008) Solid waste management in Abuja, Nigeria. *Waste Management*, **28**(2), pp.468-472.

Intergovernmental Panel on Climate Change (2006) *Regional waste generation, composition and management data* [online]. Geneva 2, Switzerland. [cited 7 April 2007]. <http://www.ipcc-nggip.iges.or.jp/public>.

Issahaku, A. (2000) The political economy of economic reform in Ghana: Implications for sustainable development. *Journal of Sustainable Development in Africa*, **2**(1), pp.13-27.

Jibril, U. (2006) Resettlement issues, squatter settlements and problems of land administration in Nigeria's Federal Capital, Abuja. *In* the Proceedings of the 5th FIG Regional Conference, Accra, Ghana, March 8-11 2006.

John, N. M., Edem, S. O., Ndaeyo, N. U. & Ndon, B. A. (2006) Physical composition of municipal solid waste and nutrient contents of its organic component in Uyo municipality, Nigeria. *Journal of Plant Nutrition*, **29**(2), pp.189-194.

Karousakis, K. & Birol, E. (2008) Investigating household preferences for kerbside recycling services in London: A choice experiment approach. *Journal of Environmental Management*, **88**(4), pp.1099-1108.

Keith, F. P. (2005) *Introduction to Social Research: Qualitative and Quantitative Approaches*. 2nd ed. London: Sage.

Kofoworola, O. F. (2007) Recovery and recycling practices in municipal solid waste management in Lagos, Nigeria. *Waste Management*, **27**(9), pp.1139-1143.

Lewcock, C. (1995) Farmer use of urban waste in Kano. *Habitat International*, **19**(2), pp.225-234.

Litwak, J. (1960) Geographical mobility and extended family cohesion. *American Sociological Review*, **25**(3), pp.385-394.

Lornage, R., Redon, E., Lagier, T., Hebe, I. & Carre, J. (2007) Performance of a low cost MBT prior to landfilling: Study of the biological treatment of size reduced MSW without mechanical sorting. *Waste Management*, **27**(12), pp.1755-1764.

Magrinho, A. & Semiao, V. (2008) On the effect of MSW moisture content on meeting target recycling rates. *Waste Management*, **28**(2), pp.310-317.

Maldonado, L. (2006) The economics of urban solid waste reduction in educational institutions in Mexico: A 3-year experience. *Resources Conservation and Recycling*, **48**(1), pp.41-55.

Malkow, T. (2004) Novel and innovative pyrolysis and gasification technologies for energy efficient and environmentally sound MSW disposal. *Waste Management*, **24**(1), pp.53-79.

Manga, V. E., Forton, O. T. & Read, A. D. (2008) Waste management in Cameroon: A new policy perspective. *Resources, Conservation and Recycling*, **52**(4), pp.592-600.

Mardia, K. V., Kent, J. T. & Bibby, J. M. (1979) *Multivariate Analysis*, Academic Press, London, United Kingdom.

Matete, N. & Trois, C. (2008) Towards Zero Waste in emerging countries - A South African experience. *Waste Management*, **28**(8), pp.1480-1492.

Matrix Consultants (1993) Sustainable solid waste management in informal settlements in Nairobi, Kenya. *In* the Proceedings of the 28th Water, Engineering and Development Conference by Loughborough University UK, held in Calcutta, India.

Mazzanti, M. & Zoboli, R. (2008) Waste generation, waste disposal and policy effectiveness: Evidence on decoupling from the European Union. *Resources, Conservation and Recycling*, **52**(10), pp.1221-1234.

Mbeng, L. O. (2009) *Impact of public attitudes and behaviours on the effective valorisation of household organic waste into agricultural compost: case study, Limbe and Doula-Cameroon*. Ph.D Thesis, University of Northampton, United Kingdom.

McCarthy, J. E. (1993) Recycling and Reducing Packaging Waste - How the United-States Compares to Other Countries. *Resources Conservation and Recycling*, **8**(3-4), pp.293-360.

McDonald, S. & Oates, C. (2003) Reasons for non-participation in a kerbside recycling scheme. *Resources, Conservation and Recycling*, **39**(4), pp.369-385.

Mee, N., Clewes, D., Phillips, P. S. & Read, A. D. (2004) Effective implementation of a marketing communications strategy for kerbside recycling: a case study from Rushcliffe, UK. *Resources Conservation and Recycling*, **42**(1), pp.1-26.

Miranda, M. L. & Hale, B. (1997) Waste not, want not: the private and social costs of waste-to-energy production. *Energy Policy*, **25**(6), pp.587-600.

Miyajima, T., Wada, E., Hanba, T.Y & Vijarnsorn, P. (1997) Anaerobic mineralization of indigenous organic matters and methanogenesis in tropical wetland soils. *Geochemical et Cosmochemica Acta* **61**, pp.2739-3751.

Mohammed, S. O., Akinyede, C. J. & Nwagwu, C. J. (1999) *Abuja image map*, 1: 25, 000. FCT and FCC Index Maps, National Space Research and Development Agency (NASRDA), Abuja.

Morgan, D. L. (1998) *Focus Groups as Qualitative Research, Qualitative Research Series 16*. London. Sage Publications Inc.

Morgan, R. W. & Kannisto, V. (1973) A population dynamics survey in Lagos, Nigeria. *Social Science & Medicine (1967)*, **7**(1), pp.1-30.

Morrissey, A. J. & Phillips, P. S. (2007) Biodegradable municipal waste (BMW) management strategy in Ireland: A comparison with some key issues in the BMW strategy being adopted in England. *Resources, Conservation and Recycling*, **49**(4), pp.353-371.

Munn, P. & Drever, E. (1990) *Using questionnaires in small-scale research: A teachers' guide*, SCRE, Edinburgh.

National Population Commission, NPC (2008) *2007 population census figures* [online]. Abuja. [cited 28 August 2008]. <http://www.population.gov.ng>.

National Economic Empowerment and Development Strategy, NEEDS (2004) *Meeting Everyone's Needs*. Nigerian National Planning Commission, Abuja.

New Agriculturist (2007) Country profile: Nigeria. [online] a project of the UK Department for International Development (DFID). [cited 3 May 2007]. <http://www.new-ag.info/country/profile>.

Nigerian Meteorological Agency, NIMET (2008a) *Quarterly Weather Report*, **1**(Issue No. 001), pp.2-7.

Nigerian Meteorological Agency, NIMET (2008b) *Quarterly Weather Report*, **1**(Issue No. 002), pp.1-28.

Nissim, I., Shohat, T. & Inbar, Y. (2005) From dumping to sanitary landfills - solid waste management in Israel. *Waste Management*, **25**(3), pp.323-327.

Nuhu, B. B. (2008) *An investigation into the use of construction delay and disruption analysis methodologies*. Ph.D Thesis, University of Wolverhampton.

Nzeadibe, T. C. (2009) Solid waste reforms and informal recycling in Enugu urban area, Nigeria. *Habitat International*, **33**(1), pp.93-99.

Obera, B. & Oyier, M. (2002) Sustainable Solid Waste Management for Kisumu, Kenya. *In* the Proceedings of the 28th Water, Engineering and Development Conference by Loughborough University UK, held in Calcutta, India.

Odunfa, A. (2007) *Municipal solid waste generation, transfer and disposal in Abuja*. Interviewed by: Ezeah, C., via telephone from The University of Wolverhampton, Wolverhampton, 20th December, 2007.

Ogu, V. I. (2000) Private sector participation and municipal waste management in Benin City, Nigeria. *Environment and Urbanization*, **12**(2), pp.103-117.

Olowomeye, R. (1991) *The Management of Solid Waste in Nigerian cities*. New York & London. Garland Publishing, Inc.

Oppenheim, A. N. (1992) *Questionnaire design, interviewing and attitude measurement*, Pinter Publishers, London, United Kingdom.

Osibanjo, O. & Nnorom, I. C. (2009) Material flows of mobile phones and accessories in Nigeria: Environmental implications and sound end-of-life management options. *Environmental Impact Assessment Review*, **28**(2-3), pp.198-213.

Otoniel, B. D., Liliana, M.-B. & Francelia, P. G. (2008) Consumption patterns and household hazardous solid waste generation in an urban settlement in México. *Waste Management*, **28**(Supplement 1), pp.S2-S6.

Parizeau, K., Maclaren, V. & Chanthy, L. (2006) Waste characterization as an element of waste management planning: Lessons learned from a study in Siem Reap, Cambodia. *Resources Conservation and Recycling*, **49**(2), pp.110-128.

Parrot, L., Sotamenou, J. & Dia, B. K. (2009) Municipal solid waste management in Africa: Strategies and livelihoods in Yaoundé, Cameroon. *Waste Management*, **29**(2), pp.986-995.

Pearce, D. Kerry, T. (1994) Solid waste management in the developing world. *In* New Directions in Solid Waste Management Conference, University of Birmingham [online]. [cited 24 June 2008] <http://www.uea.ac.uk>.

Phillips, P. S., Gronow, B. & Read, A. D. (1998) A regional perspective on waste minimisation: a case study of the East Midlands of England. *Resources, Conservation and Recycling*, **23**(3), pp.127-161.

Phillips, P. S., Pratt, R. M. & Pike, K. (2001) An analysis of UK waste minimization clubs: key requirements for future cost effective developments. *Waste Management*, **21**(4), pp.389-404.

Phillips, P. S., Read, A. D., Green, A. E. & Bates, M. P. (1999) UK waste minimisation clubs: a contribution to sustainable waste management. *Resources, Conservation and Recycling*, **27**(3), pp.217-247.

Phillips, P. S., Holley, K., Bates, M. P. & Freestone, N. P. (2002) Corby Waste Not: an appraisal of the UK's largest holistic waste minimisation project. *Resources, Conservation and Recycling*, **36**(1), pp.1-31.

Phillips, P. S., Dempsey, M., Freestone, N. P. & Read, A. D. (2004) A radical new proposal for delivering and financing waste minimisation clubs in England, due to the loss of landfill tax credit scheme funding. *Resources, Conservation and Recycling*, **43**(1), pp.35-50.

Phillips, P. S., Barnes, R., Bates, M. P. & Coskeran, T. (2006) A critical appraisal of an UK county waste minimisation programme: The requirement for regional facilitated development of industrial symbiosis/ecology. *Resources Conservation and Recycling*, **46**(3), pp.242-264.

Phillips, P. S., Clarkson, P., Adams, J., Read, A. D. & Coggins, P. C. (2003) County waste minimization programmes: A case study from Northamptonshire, UK. *Sustainable Development*, **11**(2), pp.103-118.

Pole, C. J. & Lampard, R. (2002) *Practical Social Investigation: Qualitative and Quantitative Methods in Social Research*. Essex: Pearson Education Limited.

Polkowane Declaration (2001) *The Polkowane declaration on waste management*, Polkowane, Northern Province, South Africa [online], [cited 6 January 2008], <http://soer.deat.gov.za>.

Pratt, R. M. & Phillips, P. S. (2000) The role and success of UK waste minimisation clubs in the correction of market and information failures. *Resources, Conservation and Recycling*, **30**(3), pp.201-219.

Price, J. L. (2001) The landfill directive and the challenge ahead: demands and pressures on the UK householder. *Resources, Conservation and Recycling*, **32**(3-4), pp.333-348.

Purandare, A. & Purandare, J. (2004) Municipal solid waste handing in India: special reference to Pune City. *In* Popov, V., Itoh, H., Brebbia, C. A. and Kungolos, A. (eds.) *Waste Management and the Environment*, pp.501-508.

Rathi, S. (2006) Alternative approaches for better municipal solid waste management in Mumbai, India. *Waste Management*, **26**(10), pp.1192-1200.

Read, A. D. (1999) Making waste work: making UK national solid waste strategy work at the local scale. *Resources Conservation and Recycling*, **26**(3-4), pp.259-285.

Read, A. D. (2001) Delivering sustainable waste management - a UK perspective. *Resources Conservation and Recycling*, **32**(3-4), pp.173-179.

Read, A. D., Phillips, P. S. & Murphy, A. (1997) English county councils and their agenda for waste minimisation. *Resources, Conservation and Recycling*, **20**(4), pp.277-294.

Read, M., Gregory, M. K. & Phillips, P. S. (2009) An evaluation of four key methods for monitoring household waste prevention campaigns in the UK. *Resources, Conservation and Recycling*, **54**(1), pp.9-20.

Refsgaard, K. & Magnussen, K. (2009) Household behaviour and attitudes with respect to recycling food waste - experiences from focus groups. *Journal of Environmental Management*, **90**(2), pp.760-771.

Research Information (2008) *Determine Sample Size* [Online]. Salt Lake City: [cited 15 March, 2008] <http://www.researchinfo.com/docs/calculator>.

Roberts, C. L., Ezeah, C., Watkin, G., Philips, P. S. & Odunfa, A. (2009) An investigation of seasonal variation in municipal solid waste composition in tropical urban environments: A case study of Abuja, Nigeria (in Press). *Journal of Solid Waste Technology and Management*.

Rosenthal, R. & Rosnow, R. L. (1991a) *Essentials of Behavioural Research: Methods and Data Analysis*, New York; London, McGraw-Hill.

Rosenthal, R. & Rosnow, R. L. (1991b) *Essentials of Behavioural Research: Methods and Data Analysis*, New York; London, McGraw-Hill.

Rouse, J. R. (2006) Seeking common ground for people: Livelihoods, governance and waste. *Habitat International*, **30**(4), pp.741-753.

Rushbrook, P. & Pugh, M. (1999) *Solid waste landfills in middle and lower income countries: A technical guide to planning, design and preparation*. World Bank technical paper no. 426, Washington, D.C. p2.

Rushbrook, P. E. & Finnecy, E. E. (1988) Planning for future waste management operations in developing countries. *Waste Management & Research*, **6**(1), pp.1-21.

Sakai, S., Sawell, S. E., Chandler, A. J., Eighmy, T. T., Kosson, D. S., Vehlow, J., Van Der Sloot, H. A., Hartlen, J. & Hjelmar, O. (1996) World trends in municipal solid waste management. *Waste Management*, **16**(5-6), pp.341-350.

Sakurai, K. (1990) *Improvement of solid waste management in developing countries*. Institute for International Cooperation Japan, JICA Technical Handbook Series-Vol.1.

Seliger, H. W. & Shohamy, E. (1989) *Second Language Research Methods*. Oxford: Oxford University Press.

Serpell, A. F. & Rodriguez, D. (2002) Studying construction organisational culture: Preliminary findings, In: Fellows, R. F. & Seymour, D.E. (Eds.) perspectives in culture and construction, CIB report, 275, 76-91

Sha'Ato, R., Aboho, S. Y., Oketunde, F. O., Eneji, I. S., Unazi, G. & Agwa, S. (2007) Survey of solid waste generation and composition in a rapidly growing urban area in Central Nigeria. *Waste Management*, **27**(3), pp.352-358.

Smith Korfmacher, K. (1997) Solid waste collection systems in developing urban areas of South Africa: An Overview and Case Study. *Waste Management & Research*, **15**(5), pp.477-494.

South Africa (1998) *White paper on integrated pollution and waste management for South Africa*, vol.395, No.18894. Pretoria: Department of Environmental Affairs and Tourism.

Syagga, P. (1992) Problems of solid waste management in urban residential areas in Kenya. *In* the Proceedings of Africa Research Network for Management (ARNUM) Workshop: Urban Management in Kenya, Joyce Malombe (ed) University of Nairobi in AfDB (2002).

Tabachnick, B. G. & Fidell, L. S. (2001) *Using Multivariate Statistics: International Student Edition*. 4th ed. London. Allyn and Bacon Publishers.

Tchobanoglous, G., Theisen, H. & Vigil, S. (1993) *Integrated Solid Waste Management*: *Engineering Principles and Management Issues*. New York: McGraw-Hills Inc.

The Economist (2007) Country profile: Nigeria [online]. The Economist intelligence unit [cited 15 June 2007]. <http://www.economist.com/countries/nigeria>.

Thomas, C. (1999) Waste management and recycling in Romania: a case study of technology transfer in an economy in transition. *Technovation*, **19**(6-7), pp.365-371.

Timlett, R. E. & Williams, I. D. (2008) Public participation and recycling performance in England: A comparison of tools for behaviour change. *Resources, Conservation and Recycling*, **52**(4), pp.622-634.

Tonglet, M., Phillips, P. S. & Bates, M. P. (2004a) Determining the drivers for householder pro-environmental behaviour: waste minimisation compared to recycling. *Resources, Conservation and Recycling*, **42**(1), pp.27-48.

Tonglet, M., Phillips, P. S. & Read, A. D. (2004b) Using the Theory of Planned Behaviour to investigate the determinants of recycling behaviour: a case study from Brixworth, UK. *Resources, Conservation and Recycling*, **41**(3), pp.191-214.

Torre, S. & Fjeld, T. (2001) Water loss and postharvest characteristics of cut roses grown at high or moderate relative air humidity. *Scientia Horticulturae*, **89**(3), pp.217-226.

Trankler, J., Visvanathan, C., Kuruparan, P. & Tubtimthai, O. (2005) Influence of tropical seasonal variations on landfill leachate characteristics - Results from lysimeter studies. *Waste Management*, **25**(10), pp.1013-1020.

Troschinetz, A. M. & Mihelcic, J. R. (2009) Sustainable recycling of municipal solid waste in developing countries. *Waste Management*, **29**(2), pp.915-923.

United Nations Organization, UNO (2007) *Africa and the Millennium Development Goals: 2007 Update,* [*Home Page*]. New York. [cited 14 June 2007]. Available from <http://www.un.org/millenniumgoals/>.

United Nations Conference on Environment and Development, UNCED (2007) *Institutional aspects of sustainable development in Nigeria* [online]. UN Department of Economic and Social Affairs, Division for Sustainable Development. New York. [cited 16th August 2008] <http://www.un.org/esa/agenda21>.

United Nations Environment Programme, UNEP (2007) *Nigeria's Institutional Response to the CCD, manual on compliance with enforcement of multilateral environmental agreements*. United Nations Environment Programme, Division of Environmental Laws and Conventions, Nairobi, Kenya.

United Nations Industrial Development Organization, UNIDO (2004) *Industrial development report on Nigeria* [online]. United Nations Industrial Development Organization, Vienna Austria. [cited 22 July 2008]. Available at <www.unido.org/>.

Van Der Gaast, W., Begg, K. & Flamos, A. (2009) Promoting sustainable energy technology transfers to developing countries through the CDM. *Applied Energy*, **86**(2), pp.230-236.

Von Braun, J. & Paulino, L. (1990) Food in sub-Saharan Africa : Trends and policy challenges for the 1990s. *Food Policy*, **15**(6), pp.505-517.

Walling, E., Walston, A., Warren, E., Warshay, B. & Wilhelm, E. (2004) Municipal solid waste management in developing countries: Nigeria case study. *Department of Natural Resources, Connell University, USA* [online] [cited 22 September, 2007]. < http://www.dnr.cornell.edu>

World Commission on Environment & Development, WCED (1987) *The Bruntland Report*: Report of the World Commission on Environment and Development- Our Common Future. The Bruntland Commission, United Nations Organization. New York: Available at <http://www.un-documents.net/wced-ocf.htm>.

World Development Indicators, WDI (2008) Nigeria - Country Profile. The World Bank [online]. Washington D.C.: [cited 15 August, 2008]. <http://web.worldbank.org>.

Wilson, D. C. (2007) Development drivers for waste management *Waste Management & Research*, **25**(3), pp.198-207.

Woolridge, A., Morrissey, A. & Phillips, P. S. (2005) The development of strategic and tactical tools, using systems analysis, for waste management in large complex organisations: a case study in UK healthcare waste. *Resources, Conservation and Recycling*, **44**(2), pp.115-137.

World Bank (2000) Infrastructure - Urban Development. *In* the Proceedings of African Regional Conference on Upgrading Urban Slums October 3-5, 2000, Johannesburg, South Africa.

World Resources Institute, WRI (1998) *World Resources 1998-99: A Guide to Global Environment*. Oxford: Oxford University Press.

Waste and Resource Action Programme, WRAP (2008) [*Home page*][Online]. [cited on 14 January 2008]. Available at<http://www.wrap.org.uk/wrap_corporate>.

Waste Strategy (2007) *Waste Strategy for England 2007*. Department of Environment Transport and Rural Affairs, DEFRA. London: Her Majesty's Stationery Office.

Yongsheng, Z., Henry, R. & Jun, D. (2005) Solid waste management challenges in developing countries-Kenya case study. *Waste Management*, **26**, pp.92-100.

Zotos, G., Karagiannidis, A., Zampetoglou, S., Malamakis, A., Antonopoulos, I. S., Kontogianni, S. & Tchobanoglous, G. (2009) Developing a holistic strategy for integrated waste management within municipal planning: Challenges, policies, solutions and perspectives for Hellenic municipalities in the zero-waste, low-cost direction. *Waste Management*, **29**(5), pp.1686-1692.

List of Publications

1. Ezeah, C., Roberts, C. L., Watkin, G., Philips, P. S. & Odunfa, A. (2008) Abuja: From Waste to Wealth. *In* the Proceedings of The Resource Efficiency Knowledge Transfer Network and WARMNET first Combined Conference for Postgraduate & New Researchers and industry, 30th June- 1st July, 2008, University of Nottingham, UK, vol.1 (Issue 1), p.39.

2. Ezeah, C., Roberts, C. L., Watkin, G. D, Philips, P. S. & Odunfa, A. (2009a) Analysis of barriers affecting the adoption of a sustainable municipal Solid waste management system in Nigeria. *In* the Proceedings of the 24th International Conference on Solid Waste Technology and Management, 12 - 15 March, 2009. Widener University, Philadelphia, P.A, USA, pp. 1556-1564.

3. Ezeah, C., Roberts, C. L., Phillips, P. S., Mbeng, L. O. & Nzeadibe, T. C. (2009b) Evaluation of public health impacts of waste scavenging in Abuja Nigeria, using Q-methodology. *In* the proceedings of International Solid Waste Association ISWA World Congress, 12-15 October 2009, Lisbon, Portugal.

4. Roberts, C. L., Ezeah, C., Watkin, G., Philips, P. S. & Odunfa, A. (2009) An investigation of seasonal variation in municipal solid waste composition in tropical urban environments: A case study of Abuja, Nigeria (in Press). *Journal of Solid Waste Technology and Management*.

Papers under Review

1. Ezeah, C., Roberts, C. L., Watkin, G. D, Philips, P. S. & Oduoza, C. F. (2010) Physico-chemical analysis of tropical MSW organic fractions for compost valorisation. *In* the Proceedings of Electrochem 2010: Electrochemistry and sustainability, 14-15 September 2010, University of Wolverhampton, Telford, UK.

2. Ezeah, C., Roberts, C. L., Phillips, P. S. & Nzeadibe, T. C. (2010) Focus group analysis of municipal solid waste management in Abuja, Nigeria. *In* the Proceedings of International Solid Waste Association ISWA World Congress, 15-18 November 2010, Hamburg, Germany.

3. Ezeah, C., Roberts, C. L., Phillips, P. S. & Nzeadibe, T. C. (2010) Local trends in municipal solid waste management, implementing change in public attitudes to waste management in a tropical urban slum environment. *Resources, Conservation and Recycling*.

APPENDIX

Appendix 1: Blank Copy of Questionnaire Used in the House Hold Survey

Research Centre in Applied Sciences
School of Applied Sciences
Wolverhampton, WV1 1SB
United Kingdom

INVITATION TO PARTICIPATE IN A STUDY: ANALYSIS OF BARRIERS AND SUCCESS FACTORS AFFECTING THE ADOPTION OF SUSTAINABLE MUNICIPAL SOLID WASTE (MSW) MANAGEMENT IN ABUJA, NIGERIA

The Research Centre in Applied Sciences, University of Wolverhampton is conducting a research study on municipal solid waste management in Nigeria under the guidance of Dr Clive Roberts, Dr Glynne Watkin and Prof. Paul Philips. Specifically, the research aims to analyse barriers and success factors affecting the sustainable management of municipal solid waste in Abuja, Nigeria. The project will establish parameters for assessment of improvements in performance by waste management authorities as well as prescribe strategies that will inform future policy and investment decisions

Your participation in this project is completely voluntary. It would be very much appreciated if you complete all parts of the questionnaire. The questionnaire is in four (4) parts. **Section A** requests general information about your background, **Section B** requests operational information on waste generation, recycling composting, waste transfer and disposal in your area. **Sections C** and **D** requests information about waste policy and disposal

Please note that any information you provide will be treated with the **strictest confidentiality**. At the completion of this study, all records on paper will be shredded and destroyed while electronic records will be available on a need to know basis only.

We do appreciate the questionnaire will take some of your valuable time; however it will provide a wealth of helpful information to improve waste management in Abuja. Any further information and the final outcome of the research will be available upon your request. We hope to share the results by publishing them in journals and presenting them at conferences in the UK and overseas. To this end, we would like to thank you in advance for your valued and kind consideration.

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Section A: General information

A1: Information about you

Name of respondent (Optional) _____

Contact address(Optional) _____

Tel. (Optional) _____

A2: Which area of Abuja do you reside (Please tick the right option, e.g. √)

Central Area	☐	Garki I & II	☐
Maitama	☐	Wuse I & II	☐
Asokoro	☐	Others (specify)……	☐

A3: Using the scale 1-6 (1=excellent, 6=poor), please identify your level of knowledge of the under listed waste management subjects (tick √ correct response)

	1	2	3	4	5	6	not sure
1. Waste minimization	☐	☐	☐	☐	☐	☐	☐
2. Recycling	☐	☐	☐	☐	☐	☐	☐
3. Composting	☐	☐	☐	☐	☐	☐	☐
4. Abuja Environmental Protection Board (AEPB) waste management activities	☐	☐	☐	☐	☐	☐	☐

A4: Using the scale 1-6 (1=excellent, 6=poor), could you point out how well you have done in carrying out AEPB'S environmental regulations on (tick √ correct response)

	1	2	3	4	5	6	not sure
Environmental sanitation	☐	☐	☐	☐	☐	☐	☐
Recycling	☐	☐	☐	☐	☐	☐	☐
Composting	☐	☐	☐	☐	☐	☐	☐

Section B: Operations

B1: Waste generation and collection

Please respond to the following questions relating to waste generation (tick √ correct response)					
5. Your household size (persons)	☐1	☐2 - 4	☐5 - 7	☐8 - 10	☐> 10
6. Size of accommodation	☐single room	☐room & parlour	☐ flat	☐semi-detached	☐duplex/ detached
7. Income range (Naira)	☐ <7,500	☐ 7,500-30,000	☐30,000-100,000	☐ >100,000	☐business executive
8. Residential classification (ACORN)	☐Wealthy achievers	☐Urban prosperity	☐Comfortably off	☐Moderate means	☐Hard pressed
9. Type of container used for waste collection	☐ standard bin (240 L)	☐Other covered bins	☐black bin bag	☐communal bins	☐open container
10. Who is responsible for collection and transfer of your waste	☐AEPB	☐contractors	☐informal agents/vendors	☐yourself	☐others
11. Estimate of weekly volume of waste generated from your residence	☐> standard bin	☐< 240 L bin	☐> 1 bin bag	☐< 1 bag	☐varies
12. On the average how much do you spend on waste services per month (Naira)	☐<500	☐500-1000	☐1000- 5000	☐> 5000	☐varies

B2: Recycling, composting and waste transfer

Please respond to the following statements as honestly as possible (tick √ correct response)				
13. How much of your cooked food or food purchases end up being thrown into your waste bin	☐ < 10%	☐ 10-29%	☐ 30-49%	☐ above 50%
14. Estimate of recyclable items sometimes disposed off in your bin	☐ <10%	☐ 10-29%	☐ 30-49%	☐ above 50%
15. Estimate the proportion of your possible waste that you re-use	☐ 0%	☐ 1-10%	☐ 11-20	☐above 20%
16. I do not recycle/compost but would like to if	☐ I am trained	☐I have a recycling bin	☐ If the law compels me	☐If I have some incentives
17. Being paid for recyclables will increase recycling rate	☐ Yes	☐ No	☐ Not really	☐ don't know
18. Scavenging (informal sector recycling) is useful because/for	☐ It creates employment	☐provision of raw materials	☐ cleaning the environment	☐ don't know

19. Please mention other reasons why you consider scavenging useful…….
……..

20. Please suggest ways to make Abuja residents

1. Recycle more .....

2. Compost more .....

Section C: Waste policy and strategy

C1: Barriers affecting sustainable management of municipal solid waste in Abuja

Please respond to the following statements as honestly as possible (tick √ correct response)

21. How would you index your Level of satisfaction with services provided by the AEPB	☐very satisfactory	☐ good	☐ satisfactory	☐ fair	☐ poor	☐very poor	☐ not sure

22. Please use the scale to indicate how the following barriers affect waste management in Abuja.
A value of **1** will imply **minor barrier** while **6** implies factor is a **major barrier** to waste management in the city

	1	**2**	**3**	**4**	**5**	**6**	**not sure**
Waste policies lack clear strategies for action	☐	☐	☐	☐	☐	☐	☐
Laws regulating waste management are inadequate	☐	☐	☐	☐	☐	☐	☐
Waste management institutions are weak	☐	☐	☐	☐	☐	☐	☐
Unplanned aspects of the city make waste collection difficult	☐	☐	☐	☐	☐	☐	☐
Density and high moisture content makes waste difficult to manage	☐	☐	☐	☐	☐	☐	☐
Availability of dumping grounds discourages expensive investment in alternative disposal methods	☐	☐	☐	☐	☐	☐	☐
Limited funds available are sometimes misused	☐	☐	☐	☐	☐	☐	☐
Public education on waste management is low	☐	☐	☐	☐	☐	☐	☐
Waste workers are poorly trained and poorly paid	☐	☐	☐	☐	☐	☐	☐
Operational equipment are obsolete and insufficient	☐	☐	☐	☐	☐	☐	☐

Please list other factors that could constitute barriers to sustainable waste management in the city

1……..

2……..

3……

C2: Waste management strategy (please tick √ correct response)

23. How would you rate the effectiveness of current practice for managing municipal solid waste in Abuja	☐ excellent	☐good	☐poor	☐don't know
24. Please suggest an environmentally friendly way to manage solid waste in Abuja	☐waste minimization	☐recycling/ composting	☐energy generation	☐ landfilling
25. In your opinion who is best equipped to manage the waste problem in the city	☐government agencies	☐private organizations	☐joint government and private	☐ individuals
26. Waste facilities in the city are at times located without proper environmental consideration	☐ Yes	☐ No	☐Don't know	

C3: Success factors affecting sustainable management of municipal solid waste in Abuja

27. Please use the scale to indicate how the following success factors will affect waste management in Abuja.
A value of **1** will imply factor **minimal effect** while **6** implies factor has **major effect**.

	1	**2**	**3**	**4**	**5**	**6**	**not sure**
A culture of informal sector recycling (scavenging) already exists in the city	☐	☐	☐	☐	☐	☐	☐
Waste stream is highly compostable	☐	☐	☐	☐	☐	☐	☐
Large city population is a potential market for recycled products and compost	☐	☐	☐	☐	☐	☐	☐
Recent emergence of small scale industries	☐	☐	☐	☐	☐	☐	☐

Section D: Waste disposal and environmental health

Please respond to the following statements as honestly as possible (√ correct response/s)

28. Who is responsible for the disposal of waste generated from your home?	☐ AEPB	☐ Private contractors	☐ Scavengers	☐Yourself
29. Some people dump waste in un- authorized places because	☐ no facilities	☐ Inadequate information	☐ No penalty	☐ To save cost
30. The commonest method of waste disposal in my area is	☐ Sanitary landfills	☐ Open dumping	☐ Burning	☐ Incinerat-ors

31. Please mention some major health concerns associated with waste scavenging in your area
1.……
2.……
3.……..

ANY OTHER COMMENTS

……
……
……
……
…….

Will you be available for a brief follow-up confidential interview?

Yes ☐

No ☐

Thank you for completing the questionnaire.

Appendix 2: Summary of solid waste generation and waste characteristics in Makurdi urban area over a 10 day survey period (July/August, 2003)

waste generator	10 day survey period (kg)			total generation (kg)	daily total generation (kg)			moisture/ day (kg)	Bulk Density (kg/m^3)			per capita generation/day
	range	Av. Per type	SD		range	Av. Per type	SD		range	Av. Per type	SD	
LoDA(HH)	17.4-117.3	45.5	30.0	683.2	51.2-98.7	73.8	13.0	30.1	180-377	273.0	61.0	0.6
MeDA(HH)	6.1-100.3	27.3	20.0	807.9	64-105.2	80.8	14.0	28.5	166-296	249.0	41.0	0.4
HiDA(HH)	6.3-279.6	92.3	59.0	4429.0	335.5-541.2	422.9	71.3	21.7	392-412	337.0	36.0	0.6
Overall(HH)	6.1-279.6	64.4	55.0	5920.0	484-714	592.0	75.0	26.8	166-412	287.0	45.0	0.5
Commercial	4.6-208	69.4	70.2	763.0	61.9-104.1	82.2	11.0	26.0	203-399	289.0	53.0	0.0
Institutional	11-173	64.0	63.0	318.5	16.5-40.6	31.9	8.1	22.7	113-275	170.0	61.0	0.0
SMI	30.3-72.6	45.1	19.0	180.3	9.0-24.0	18.1	4.7	19.5	55-206	138.0	60.0	0.5
Overall(NHH)	4.6-208	63.1	60.4	1262.0	9-104	44.0	28.8	22.7	55-399	200.0	87.0	0.2
MART 710kg/day				6386.0	422-1069	710.0	174.0	32.0	248-629	425.0	94.0	

Source: (Sha'Ato *et al.*, 2007)

Notes:

HiDA = High density area (50 households).

MeDA = Medium density area (30 households).

LoDA = Low density area (15 households).

COMM = Commercial premises; INS = Institutional premises; SMIs = Small to medium scale industry; MART = Wadata market.

A = waste collected from individual households (HH) in 10 days e.g. for the "Range" one household totalled 17.4 kg in 10 days while another totalled 117.3 kg in the same period in LoDA.

B = Pooled (i.e. all households) total waste collected per day e.g. all HH in LoDA gave a lowest waste quantity of 51.2 kg on 1 day and a highest waste quantity of 98.7 kg on another day.

C = Per capita generation: kg/person / day for COMM, INS and SMI; kg/day for MART.

Appendix 3a: MONTHLY MEAN OF MAXIMUM TEMPERATURE (•C)

	MONTHLY MEAN OF MAXIMUM TEMPERATURE (1997-2006)												
STN	YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
ABUJA	1997	36.1	37.6	37.2	34.1	32.0	31.0	29.5	29.5	30.9	31.3	33.2	34.2
	1998	35.3	38.0	38.1	37.6	33.4	31.1	29.1	28.3	29.7	31.1	34.5	35.2
	1999	35.4	36.8	36.9	36.0	32.7	31.0	28.9	28.8	29.4	30.7	34.2	35.2
	2000	35.9	35.8	38.2	35.3	33.7	30.6	29.0	28.9	30.0	31.2	35.0	34.7
	2001	34.7	36.5	37.8	35.5	33.4	31.0	29.0	28.6	28.8	32.3	35.6	36.3
	2002	35.1	36.3	36.9	34.7	34.2	31.7	29.6	28.9	29.7	31.1	33.8	35.4
	2003	35.5	37.3	37.5	35.2	34.5		29.8	29.1	29.8	31.7	32.1	34.5
	2004	34.8	37.3	37.8	35.0	31.7	30.7	29.9	28.9	30.3	31.7	33.2	35.1
	2005	34.5	38.0	38.0	36.2	32.5	30.5	29.5	28.5	30.3	31.3	34.6	35.0
	2006	35.7	36.1	36.0	37.3	32.3	31.4	30.1	28.1	29.6	31.1	33.8	35.3

Appendix 3b: MONTHLY MEAN OF MINIMUM TEMPERATURE (°C)

	MONTHLY MEAN OF MINIMUM TEMPERATURE (1997-2006)												
STN	YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
ABUJA	1997	18.8	18.6	24.1	23.2	22.1	22.1	22.2	21.9	21.6	21.6	20.3	17.8
	1998	17.4	22.4	24.1	25.0	24.4	22.0	22.4	22.1	22.2	22.1	19.7	18.2
	1999	18.9	22.0	24.6	24.2	23.1	22.6	22.1	22.0	21.6	23.0	20.4	23.1
	2000	19.3	19.8	23.3	24.8	23.7	21.9	22.0	21.9	21.7	21.9	19.9	17.6
	2001	17.3	20.4	24.3	25.0	24.4	22.4	22.2	21.7	21.6	22.0	20.1	18.6
	2002	17.7	21.1	25.0	25.2	24.7	22.8	22.3	22.2	21.9	22.3	20.4	18.1
	2003	19.7	22.4	25.1	25.0	24.7		22.5	22.3	22.3	22.5	20.8	17.6
	2004	19.2	21.5	24.5	25.1	23.5	22.7	22.3	22.2	22.1	22.5	21.4	18.6
	2005	18.5	24.8	26.3	25.6	24.0	22.9	22.9	22.6	22.5	22.1	20.0	19.7
	2006	22.5	24.6	25.4	25.1	23.8	23.4	23.1	22.1	22.2	22.4	19.5	16.9

Appendix 3c: MONTHLY TOTAL OF RAINFALL (mm)

	MONTHLY TOTAL OF RAINFALL (1997-2006)												
STN	YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
ABUJA	1997	0	0	27	76.7	166.6	193.8	186.9	225	247.2	198.3	9.5	5.3
	1998	0	0.3	19	107.4	101.4	241.6	310	196.1	157.3	322	0	0
	1999	0	0	20.6	81.9	227.8	162.1	345.4	344.8	282.5	194.8	8	0
	2000	0	0	0	58.3	138.6	144.7	276.6	214.8	255.2	110.1	0	0
	2001	0	0	0.5	96	94.5	152.6	358.5	333.4	245.9	101.6	0	0
	2002	0	0	70.5	0	82	227.7	450.3	487.8	353.1	263.3	6.9	0
	2003	0	24	19.3	82	167.7		482.7	257.6	249.5	82.2	63.3	0
	2004	0	11.5	0	64.3	222	310.7	255.6	303.6	164.9	202.7	5.9	0
	2005	0	0	0	63.2	93.2	477	275.7	202.4	158.3	202	0	0
	2006	13.2	21.5	46.6	32.5	136.2	101.1	189.8	384.5	186.6	199.6	0	0

Appendix 3d: MONTHLY MEAN OF RELATIVE HUMIDITY (%)

STN	MONTHLY MEAN OF RELATIVE HUMIDITY(0900Z) [1997- 2005]												
	YR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
ABUJA	1997	53	31	54	73	85	87	91	91	90	91	87	68
	1998	51	42	39	61	80	89	91	92	91	91	79	62
	1999	57	53	63	65	80	87	91	91	93	91	81	61
	2000	52	31	40	67	79	86	89	91	92	89	75	59
	2001	51	36	49	67	79	87	91	92	91	87	72	60
	2002	40	42	58	73	77	83	90	93	91	91	81	62
	2003	57	51	47	71	74	89	89	92	90	90	84	66
	2004	54	35	39	68	84	89	91	92	91	89	82	68
	2005	44	49	54	63	81	87	92	89	91	89	74	66

Appendix 3e: MONTHLY MEAN OF RELATIVE HUMIDITY (%)

	MONTHLY MEAN OF RELATIVE HUMIDITY(1500Z) [1997-2005]												
STN	YR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
ABUJA	1997	27	15	33	52	62	68	71	72	67	71	52	32
	1998	25	24	23	42	59	68	73	76	71	66	40	29
	1999	27	31	36	41	58	63	74	72	72	66	41	23
	2000	24	16	22	45	54	64	75	70	73	62	35	28
	2001	24	18	29	43	57	65	77	76	74	58	32	26
	2002	21	25	37	51	53	64	73	75	71	66	40	27
	2003	29	27	27	49	52	69	69	74	70	67	45	27
	2004	27	22	25	48	65	67	74	73	71	82	50	30
	2005	23	32	34	43	60	69	74	73	71	64	38	32

Appendix 4: Descriptive statistics of interaction between waste composition and seasons

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Boundary	Upper Boundary		
PAPER	1	80	7.037	7.9863	0.8929	5.260	8.814	0.1	34.0
	2	80	6.766	7.1185	0.7959	5.182	8.350	0.0	43.4
	Total	160	6.902	7.5423	0.5963	5.724	8.079	0.0	43.4
CARDBOARD	1	80	8.888	9.3639	1.0469	6.805	10.972	0.0	45.3
	2	80	7.656	7.2115	0.8063	6.051	9.261	0.0	27.6
	Total	160	8.272	8.3538	0.6604	6.968	9.577	0.0	45.3
PLASTIC FILM	1	80	12.460	10.4363	1.1668	10.138	14.782	1.5	67.6
	2	80	10.949	6.7772	0.7577	9.441	12.457	0.4	35.7
	Total	160	11.704	8.8041	0.6960	10.330	13.079	0.4	67.6
DENSE PLASTIC	1	80	6.901	10.2324	1.1440	4.624	9.178	0.0	59.4
	2	80	4.061	4.3898	0.4908	3.084	5.038	0.0	27.8
	Total	160	5.481	7.9766	0.6306	4.236	6.727	0.0	59.4
GLASS	1	80	3.741	7.7713	0.8689	2.011	5.470	0.0	36.0
	2	80	1.621	3.9067	0.4368	0.752	2.491	0.0	24.4
	Total	160	2.681	6.2225	0.4919	1.709	3.652	0.0	36.0
METALS & CANS	1	80	2.519	4.0067	0.4480	1.627	3.411	0.0	29.4

	2	80	3.530	9.3944	1.0503	1.439	5.621	0.0	62.5
	Total	160	3.025	7.2169	0.5705	1.898	4.151	0.0	62.5
NON-FERROUS METALS	1	80	1.620	9.5765	1.0707	-0.511	3.751	0.0	74.2
	2	80	0.327	1.0266	0.1148	0.099	0.556	0.0	6.5
	Total	160	0.974	6.8198	0.5392	-0.091	2.039	0.0	74.2
PUTRISCIBLES	1	80	46.633	22.4288	2.5076	41.642	51.624	0.0	84.6
	2	80	49.469	19.5070	2.1810	45.128	53.810	0.0	86.4
	Total	160	48.051	21.0008	1.6603	44.772	51.330	0.0	86.4
TEXTILES	1	80	1.671	3.9635	0.4431	0.789	2.553	0.0	20.0
	2	80	2.076	4.5675	0.5107	1.060	3.093	0.0	25.3
	Total	160	1.874	4.2676	0.3374	1.207	2.540	0.0	25.3
MISC-COMBUSTIBLES	1	80	1.655	3.5565	0.3976	0.864	2.447	0.0	17.3
	2	80	4.942	9.4485	1.0564	2.840	7.045	0.0	62.1
	Total	160	3.299	7.3047	0.5775	2.158	4.439	0.0	62.1
MISC NON-COMBUSTIBLES	1	80	1.235	3.0945	0.3460	0.546	1.923	0.0	19.4
	2	80	2.643	7.6141	0.8513	0.948	4.337	0.0	57.0
	Total	160	1.939	5.8362	0.4614	1.027	2.850	0.0	57.0
WEE	1	80	0.365	1.1311	0.1265	0.113	0.617	0.0	8.6
	2	80	1.490	5.0161	0.5608	0.374	2.606	0.0	38.7
	Total	160	0.927	3.6682	0.2900	0.355	1.500	0.0	38.7

HHW	1	80	0.000	0.0000	0.0000	0.000	0.000	0.0	0.0
	2	80	0.171	0.5515	0.0617	0.049	0.294	0.0	3.4
	Total	160	0.086	0.3981	0.0315	0.023	0.148	0.0	3.4
FINE ELEMENTS	1	80	4.555	11.0395	1.2342	2.099	7.012	0.0	64.0
	2	80	4.320	9.8138	1.0972	2.136	6.504	0.0	66.4
	Total	160	4.438	10.4124	0.8232	2.812	6.063	0.0	66.4

Appendix 5: Descriptive statistics of interaction between waste composition and sampling zones

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Boundary	Upper Boundary		
PAPER	1	20	4.344	3.3435	.7476	2.779	5.908	0.7	11.6
	2	20	6.085	4.9406	1.1048	3.773	8.397	0.0	19.1
	3	20	5.665	6.5975	1.4753	2.577	8.753	0.3	31.2
	4	20	7.055	10.1164	2.2621	2.320	11.790	0.0	34.0
	5	20	7.610	7.9066	1.7680	3.910	11.310	0.7	29.2
	6	20	11.345	11.1624	2.4960	6.121	16.569	0.8	43.4
	7	20	7.020	6.9992	1.5651	3.744	10.296	0.0	20.2
	8	20	6.090	5.2192	1.1670	3.647	8.533	0.0	24.7
	Total	160	6.902	7.5423	.5963	5.724	8.079	0.0	43.4
CARDBOARD	1	20	5.219	9.9174	2.2176	.577	9.860	0.0	43.0
	2	20	9.425	9.8013	2.1916	4.838	14.012	1.3	45.3
	3	20	7.925	7.7934	1.7427	4.278	11.572	0.0	25.4
	4	20	9.555	9.2688	2.0726	5.217	13.893	0.0	27.6
	5	20	5.900	4.5906	1.0265	3.752	8.048	0.0	15.9
	6	20	7.265	6.5162	1.4571	4.215	10.315	0.0	26.0

	7	20	11.460	8.4279	1.8845	7.516	15.404	0.0	30.0
	8	20	9.430	8.7293	1.9519	5.345	13.515	0.3	33.6
	Total	160	8.272	8.3538	0.6604	6.968	9.577	0.0	45.3
PLASTIC FILM	1	20	11.345	7.0361	1.5733	8.052	14.638	2.9	32.6
	2	20	11.160	7.0639	1.5795	7.854	14.466	1.5	35.7
	3	20	13.195	7.5916	1.6975	9.642	16.748	4.1	29.3
	4	20	14.155	9.6299	2.1533	9.648	18.662	2.6	39.7
	5	20	14.680	13.9896	3.1282	8.133	21.227	3.7	67.6
	6	20	9.060	4.9463	1.1060	6.745	11.375	2.6	18.3
	7	20	8.005	5.1142	1.1436	5.611	10.399	1.3	22.4
	8	20	12.035	10.5942	2.3689	7.077	16.993	0.4	48.1
	Total	160	11.704	8.8041	0.6960	10.330	13.079	0.4	67.6
DENSE PLASTIC	1	20	3.146	5.9650	1.3338	.354	5.937	0.2	27.0
	2	20	7.510	13.3673	2.9890	1.254	13.766	0.3	59.4
	3	20	2.540	2.5031	0.5597	1.368	3.712	0.0	9.2
	4	20	4.375	4.5615	1.0200	2.240	6.510	0.0	14.2
	5	20	9.350	12.6648	2.8319	3.423	15.277	0.5	51.6
	6	20	6.070	7.2818	1.6283	2.662	9.478	0.6	32.1
	7	20	5.870	5.3518	1.1967	3.365	8.375	0.0	18.4
	8	20	4.990	3.4699	0.7759	3.366	6.614	0.0	12.6
	Total	160	5.481	7.9766	0.6306	4.236	6.727	0.0	59.4

GLASS	1	20	2.687	5.0813	1.1362	0.309	5.065	0.0	21.1
	2	20	1.290	2.4732	0.5530	0.133	2.447	0.0	7.4
	3	20	2.485	4.9339	1.1033	0.176	4.794	0.0	18.2
	4	20	3.185	7.7937	1.7427	-0.463	6.833	0.0	34.0
	5	20	3.980	8.8738	1.9842	-0.173	8.133	0.0	36.0
	6	20	2.130	4.1387	0.9254	0.193	4.067	0.0	16.4
	7	20	3.175	8.2461	1.8439	-0.684	7.034	0.0	29.0
	8	20	2.515	6.1971	1.3857	-0.385	5.415	0.0	27.8
	Total	160	2.681	6.2225	0.4919	1.709	3.652	0.0	36.0
METALS & CANS	1	20	4.472	13.7792	3.0811	-1.977	10.920	0.0	62.5
	2	20	4.665	12.6756	2.8344	-1.267	10.597	0.2	58.1
	3	20	1.370	1.8296	0.4091	0.514	2.226	0.0	6.4
	4	20	1.495	1.5939	0.3564	0.749	2.241	0.0	4.6
	5	20	1.835	1.8256	0.4082	0.981	2.689	0.0	7.9
	6	20	5.605	6.4639	1.4454	2.580	8.630	0.0	29.4
	7	20	2.590	2.9379	0.6569	1.215	3.965	0.0	13.4
	8	20	2.165	2.4132	0.5396	1.036	3.294	0.0	8.1
	Total	160	3.025	7.2169	0.5705	1.898	4.151	0.0	62.5
NON-FERROUS METALS	1	20	0.370	1.4481	0.3238	-0.308	1.048	0.0	6.5
	2	20	0.075	0.2489	0.0557	-0.042	0.192	0.0	1.1
	3	20	4.430	16.6867	3.7313	-3.380	12.240	0.0	74.2

	4	20	2.185	9.3977	2.1014	-2.213	6.583	0.0	42.1
	5	20	0.000	0.0000	0.0000	0.000	<0.001	0.0	0.0
	6	20	0.145	0.3154	0.0705	-0.003	0.293	0.0	1.1
	7	20	0.445	1.4051	0.3142	-0.213	1.103	0.0	6.0
	8	20	0.140	0.3455	0.0773	-0.022	0.302	0.0	1.4
	Total	160	0.974	6.8198	0.5392	-0.091	2.039	0.0	74.2
PUTRISCIBLES	1	20	57.502	22.1313	4.9487	47.144	67.860	4.0	83.7
	2	20	47.870	20.0709	4.4880	38.477	57.263	10.7	71.7
	3	20	49.110	20.4731	4.5779	39.528	58.692	0.0	79.0
	4	20	43.055	23.4466	5.2428	32.082	54.028	0.0	86.4
	5	20	43.340	22.5186	5.0353	32.801	53.879	0.0	86.1
	6	20	47.020	17.2211	3.8508	38.960	55.080	0.0	84.6
	7	20	47.005	17.6767	3.9526	38.732	55.278	18.1	73.3
	8	20	49.505	23.7432	5.3092	38.393	60.617	0.0	76.4
	Total	160	48.051	21.0008	1.6603	44.772	51.330	0.0	86.4
TEXTILES	1	20	0.604	0.7432	0.1662	0.256	0.952	0.0	2.7
	2	20	2.000	4.0260	0.9002	0.116	3.884	0.0	17.1
	3	20	4.020	6.8898	1.5406	0.795	7.245	0.0	25.3
	4	20	2.300	4.4290	0.9903	0.227	4.373	0.0	18.3
	5	20	2.120	3.6852	0.8240	0.395	3.845	0.0	13.7
	6	20	1.010	2.7541	0.6158	-0.279	2.299	0.0	9.5

	7	20	2.370	6.0733	1.3580	-0.472	5.212	0.0	21.3
	8	20	0.565	0.9190	0.2055	0.135	0.995	0.0	2.6
	Total	160	1.874	4.2676	0.3374	1.207	2.540	0.0	25.3
MISC-COMBUSTIBLES	1	20	4.342	5.6758	1.2691	1.685	6.998	0.0	18.6
	2	20	3.285	4.4574	0.9967	1.199	5.371	0.0	16.6
	3	20	2.340	4.5311	1.0132	0.219	4.461	0.0	14.8
	4	20	6.345	13.8956	3.1071	-0.158	12.848	0.0	62.1
	5	20	1.295	3.5750	0.7994	-0.378	2.968	0.0	15.8
	6	20	2.950	7.8550	1.7564	-0.726	6.626	0.0	35.2
	7	20	3.805	8.4841	1.8971	-0.166	7.776	0.0	31.9
	8	20	2.030	4.0210	0.8991	0.148	3.912	0.0	16.4
	Total	160	3.299	7.3047	0.5775	2.158	4.439	0.0	62.1
MISC NON-COMBUSTIBLES	1	20	1.734	4.5998	1.0285	-0.419	3.887	0.0	19.4
	2	20	1.280	2.1679	0.4847	0.265	2.295	0.0	8.1
	3	20	1.050	3.9678	0.8872	-0.807	2.907	0.0	17.8
	4	20	.760	2.2135	0.4949	-0.276	1.796	0.0	9.3
	5	20	4.365	12.7147	2.8431	-1.586	10.316	0.0	57.0
	6	20	1.575	2.9059	0.6498	0.215	2.935	0.0	9.3
	7	20	3.305	6.9792	1.5606	0.039	6.571	0.0	29.8
	8	20	1.440	2.8914	0.6465	0.087	2.793	0.0	9.0
	Total	160	1.939	5.8362	0.4614	1.027	2.850	0.0	57.0

WEE	1	20	0.819	1.1340	0.2536	0.289	1.350	0.0	3.6
	2	20	1.365	4.3789	0.9792	-0.684	3.414	0.0	19.8
	3	20	0.485	1.1013	0.2463	-0.030	1.000	0.0	4.4
	4	20	0.190	0.5476	0.1225	-0.066	0.446	0.0	2.3
	5	20	0.300	0.5361	0.1199	0.049	0.551	0.0	1.7
	6	20	0.745	1.9859	0.4441	-0.184	1.674	0.0	8.6
	7	20	0.945	2.5691	0.5745	-0.257	2.147	0.0	11.6
	8	20	2.570	8.6899	1.9431	-1.497	6.637	0.0	38.7
	Total	160	0.927	3.6682	0.2900	0.355	1.500	0.0	38.7
HHW	1	20	0.035	0.1565	0.0350	-0.038	0.108	0.0	0.7
	2	20	0.005	0.0224	0.0050	-0.005	0.015	0.0	0.1
	3	20	0.140	0.3719	0.0832	-0.034	0.314	0.0	1.5
	4	20	0.015	0.0671	0.0150	-0.016	0.046	0.0	0.3
	5	20	0.195	0.7626	0.1705	-0.162	0.552	0.0	3.4
	6	20	0.105	0.2819	0.0630	-0.027	0.237	0.0	1.1
	7	20	0.145	0.6485	0.1450	-0.158	0.448	0.0	2.9
	8	20	0.045	0.2012	0.0450	-0.049	0.139	0.0	0.9
	Total	160	0.086	0.3981	0.0315	0.023	0.148	0.0	3.4
FINE ELEMENTS	1	20	3.266	6.4367	1.4393	0.254	6.278	0.0	20.7
	2	20	3.775	5.8966	1.3185	1.015	6.535	0.0	15.1
	3	20	5.050	12.7727	2.8561	-0.928	11.028	0.0	56.1

	4	20	5.060	10.4357	2.3335	0.176	9.944	0.0	37.5
	5	20	4.640	15.0250	3.3597	-2.392	11.672	0.0	66.4
	6	20	4.530	8.4210	1.8830	0.589	8.471	0.0	31.6
	7	20	3.330	6.7287	1.5046	0.181	6.479	0.0	24.1
	8	20	5.850	14.5240	3.2477	-0.947	12.647	0.0	64.0
	Total	160	4.438	10.4124	.8232	2.812	6.063	0.0	66.4

Appendix 6: Tukey HSD post-hoc test of interaction between sampling zones and sample composition (in enclosed compact disc)

Appendix 7: Descriptive statistics of interaction between waste composition and household income classification

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Boundary	Upper Boundary		
PAPER	low income	36	4.645	5.0921	0.8487	2.922	6.368	0.0	24.5
	medium income	62	5.370	4.8916	0.6212	4.128	6.612	0.0	29.2
	high income	38	6.626	6.3904	1.0367	4.526	8.727	0.0	29.2
	unspecified	24	14.679	12.1287	2.4758	9.558	19.801	0.0	43.4
	Total	160	6.902	7.5423	0.5963	5.724	8.079	0.0	43.4
CARDBOARD	low income	36	5.116	5.5202	0.9200	3.249	6.984	0.0	25.4
	medium income	62	7.411	8.6829	1.1027	5.206	9.616	0.0	45.3
	high income	38	9.055	8.1072	1.3152	6.390	11.720	0.0	30.0
	unspecified	24	13.992	8.8114	1.7986	10.271	17.712	1.1	33.6
	Total	160	8.272	8.3538	0.6604	6.968	9.577	0.0	45.3
PLASTIC FILM	low income	36	15.065	11.3565	1.8928	11.223	18.907	3.1	67.6
	medium income	62	11.177	7.4099	0.9411	9.295	13.059	1.5	39.7
	high income	38	9.161	7.7644	1.2596	6.608	11.713	0.4	48.1
	unspecified	24	12.054	8.2298	1.6799	8.579	15.529	2.6	29.3
	Total	160	11.704	8.8041	0.6960	10.330	13.079	0.4	67.6
DENSE PLASTIC	low income	36	4.699	6.4858	1.0810	2.505	6.894	0.0	27.8

	medium income	62	4.563	7.7723	0.9871	2.590	6.537	0.0	51.6
	high income	38	5.479	6.0688	0.9845	3.484	7.474	0.0	32.1
	unspecified	24	9.029	11.8326	2.4153	4.033	14.026	0.0	59.4
	Total	160	5.481	7.9766	0.6306	4.236	6.727	0.0	59.4
GLASS	low income	36	3.737	7.2497	1.2083	1.284	6.190	0.0	36.0
	medium income	62	2.376	5.4865	0.6968	0.983	3.769	0.0	34.0
	high income	38	3.455	7.8029	1.2658	0.891	6.020	0.0	29.0
	unspecified	24	0.658	1.6291	0.3325	-0.030	1.346	0.0	7.3
	Total	160	2.681	6.2225	0.4919	1.709	3.652	0.0	36.0
METALS & CANS	low income	36	3.664	10.2865	1.7144	0.183	7.144	0.0	62.5
	medium income	62	2.663	7.3701	0.9360	0.792	4.535	0.0	58.1
	high income	38	3.689	5.3676	0.8707	1.925	5.454	0.0	29.4
	unspecified	24	1.946	2.3849	0.4868	0.939	2.953	0.0	10.5
	Total	160	3.025	7.2169	0.5705	1.898	4.151	0.0	62.5
NON-FERROUS METALS	low income	36	0.233	1.0886	0.1814	-0.135	0.602	0.0	6.5
	medium income	62	1.460	9.5406	1.2117	-0.963	3.883	0.0	74.2
	high income	38	1.339	6.8610	1.1130	-0.916	3.595	0.0	42.1
	unspecified	24	0.250	0.5718	0.1167	0.009	0.491	0.0	2.3
	Total	160	0.974	6.8198	0.5392	-0.091	2.039	0.0	74.2
PUTRISCIBLES	low income	36	50.130	21.1722	3.5287	42.966	57.293	0.0	86.4
	medium income	62	51.500	21.0467	2.6729	46.155	56.844	0.0	86.1

	high income	38	49.634	19.4079	3.1484	43.255	56.013	0.0	84.6
	unspecified	24	33.517	17.9608	3.6662	25.932	41.101	0.0	71.8
	Total	160	48.051	21.0008	1.6603	44.772	51.330	0.0	86.4
TEXTILES	low income	36	2.617	4.0457	0.6743	1.248	3.986	0.0	17.1
	medium income	62	1.896	4.7439	0.6025	0.692	3.101	0.0	25.3
	high income	38	1.545	4.6105	0.7479	0.029	3.060	0.0	21.3
	unspecified	24	1.221	2.3714	0.4841	0.219	2.222	0.0	9.5
	Total	160	1.874	4.2676	0.3374	1.207	2.540	0.0	25.3
MISC-COMBUSTIBLES	low income	36	3.115	5.1222	0.8537	1.382	4.848	0.0	16.6
	medium income	62	3.766	8.8171	1.1198	1.527	6.005	0.0	62.1
	high income	38	2.476	6.3433	1.0290	0.391	4.561	0.0	31.9
	unspecified	24	3.671	7.4918	1.5293	0.507	6.834	0.0	35.2
	Total	160	3.299	7.3047	0.5775	2.158	4.439	0.0	62.1
MISC NON-COMBUSTIBLES	low income	36	2.543	9.6155	1.6026	-0.711	5.796	0.0	57.0
	medium income	62	1.628	3.8472	0.4886	0.651	2.605	0.0	19.4
	high income	38	1.979	5.2743	0.8556	0.245	3.713	0.0	29.8
	unspecified	24	1.771	3.1461	0.6422	0.442	3.099	0.0	10.4
	Total	160	1.939	5.8362	0.4614	1.027	2.850	0.0	57.0
WEE	low income	36	0.278	0.5822	0.0970	0.081	0.475	0.0	2.5
	medium income	62	0.977	2.7559	0.3500	0.277	1.677	0.0	19.8
	high income	38	0.534	1.9349	0.3139	-0.102	1.170	0.0	11.6

	unspecified	24	2.396	7.9476	1.6223	-0.960	5.752	0.0	38.7
	Total	160	0.927	3.6682	0.2900	0.355	1.500	0.0	38.7
HHW	low income	36	0.156	0.6148	0.1025	-0.052	0.364	0.0	3.4
	medium income	62	0.048	0.1940	0.0246	0.000	0.098	0.0	1.1
	high income	38	0.047	0.1782	0.0289	-0.011	0.106	0.0	0.9
	unspecified	24	0.137	0.5940	0.1213	-0.113	0.388	0.0	2.9
	Total	160	0.086	0.3981	0.0315	0.023	0.148	0.0	3.4
FINE ELEMENTS	low income	36	3.778	8.5969	1.4328	0.869	6.687	0.0	37.5
	medium income	62	4.875	11.7349	1.4903	1.894	7.855	0.0	66.4
	high income	38	4.439	12.0795	1.9596	0.469	8.410	0.0	64.0
	unspecified	24	4.296	5.9880	1.2223	1.767	6.824	0.0	20.4
	Total	160	4.438	10.4124	0.8232	2.812	6.063	0.0	66.4

Appendix 8: Tukey HSD post-hoc test of interaction between household income and sample composition

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) INCCLASS	(J) INCCLASS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Boundary	Upper Boundary
PAPER	low income	medium income	-0.7247	1.4296	0.957	-4.437	2.988
		high income	-1.9810	1.5868	0.597	-6.102	2.140
		unspecified	-10.0339*	1.7979	<0.001	-14.703	-5.365
	medium income	low income	0.7247	1.4296	0.957	-2.988	4.437
		high income	-1.2563	1.4056	0.808	-4.907	2.394
		unspecified	-9.3092*	1.6402	<0.001	-13.569	-5.050
	high income	low income	1.9810	1.5868	0.597	-2.140	6.102
		medium income	1.2563	1.4056	0.808	-2.394	4.907
		unspecified	-8.0529*	1.7789	<0.001	-12.673	-3.433
	unspecified	low income	10.0339*	1.7979	<0.001	5.365	14.703
		medium income	9.3092*	1.6402	<0.001	5.050	13.569
		high income	8.0529*	1.7789	<0.001	3.433	12.673
CARDBOARD	low income	medium income	-2.2946	1.6678	0.516	-6.626	2.037
		high income	-3.9389	1.8512	0.149	-8.746	0.869

		unspecified	-8.8753*	2.0975	<0.001	-14.322	-3.428
	medium income	low income	2.2946	1.6678	0.516	-2.037	6.626
		high income	-1.6443	1.6398	0.748	-5.903	2.614
		unspecified	-6.5807*	1.9135	0.004	-11.550	-1.611
	high income	low income	3.9389	1.8512	0.149	-0.869	8.746
		medium income	1.6443	1.6398	0.748	-2.614	5.903
		unspecified	-4.9364	2.0753	0.085	-10.326	0.453
	unspecified	low income	8.8753*	2.0975	<0.001	3.428	14.322
		medium income	6.5807*	1.9135	0.004	1.611	11.550
		high income	4.9364	2.0753	0.085	-0.453	10.326
PLASTIC FILM		medium income	3.8882	1.8109	0.143	-0.815	8.591
		high income	5.9045*	2.0100	0.020	0.685	11.124
		unspecified	3.0108	2.2775	0.550	-2.904	8.925
		low income	-3.8882	1.8109	0.143	-8.591	0.815
		high income	2.0162	1.7805	0.670	-2.608	6.640
		unspecified	-0.8774	2.0777	0.975	-6.273	4.518
		low income	-5.9045*	2.0100	0.020	-11.124	-0.685
		medium income	-2.0162	1.7805	0.670	-6.640	2.608
		unspecified	-2.8936	2.2534	0.574	-8.745	2.958
		low income	-3.0108	2.2775	0.550	-8.925	2.904
		low income		2.0777	0.975	-4.518	6.273

				2.2534	.574	-2.958	8.745
DENSE PLASTIC	low income			1.6557	1.000	-4.164	4.436
			medium income	1.8378	0.974	-5.552	3.993
				2.0823	0.164	-9.737	1.078
	medium income			1.6557	1.000	-4.436	4.164
			high income	1.6279	0.943	-5.143	3.312
				1.8996	0.091	-9.399	0.467
	high income			1.8378	0.974	-3.993	5.552
			unspecified	1.6279	0.943	-3.312	5.143
				2.0602	0.315	-8.901	1.800
	unspecified			2.0823	0.164	-1.078	9.737
		medium income	4.4658	1.8996	0.091	-0.467	9.399
		high income	3.5502	2.0602	0.315	-1.800	8.901
GLASS	low income	medium income	1.3605	1.2984	0.722	-2.011	4.732
		high income	0.2814	1.4412	0.997	-3.461	4.024
		unspecified	3.0783	1.6329	0.239	-1.162	7.319
	medium income	low income	-1.3605	1.2984	0.722	-4.732	2.011
		high income	-1.0791	1.2766	0.833	-4.394	2.236
		unspecified	1.7178	1.4897	0.657	-2.151	5.586

	high income	low income	-0.2814	1.4412	0.997	-4.024	3.461
		medium income	1.0791	1.2766	0.833	-2.236	4.394
		unspecified	2.7969	1.6156	0.311	-1.399	6.993
	unspecified	low income	-3.0783	1.6329	0.239	-7.319	1.162
		medium income	-1.7178	1.4897	0.657	-5.586	2.151
		high income	-2.7969	1.6156	0.311	-6.993	1.399
METALS & CANS	low income	medium income	1.0005	1.5204	0.913	-2.948	4.949
		high income	-0.0256	1.6876	1.000	-4.408	4.357
		unspecified	1.7181	1.9122	0.806	-3.248	6.684
	medium income	low income	-1.0005	1.5204	0.913	-4.949	2.948
		high income	-1.0261	1.4949	0.902	-4.908	2.856
		unspecified	0.7176	1.7444	0.976	-3.813	5.248
	high income	low income	0.0256	1.6876	1.000	-4.357	4.408
		medium income	1.0261	1.4949	0.902	-2.856	4.908
		unspecified	1.7436	1.8919	0.793	-3.170	6.657
	unspecified	low income	-1.7181	1.9122	0.806	-6.684	3.248
		medium income	-0.7176	1.7444	0.976	-5.248	3.813
		high income	-1.7436	1.8919	0.793	-6.657	3.170
NON-FERROUS METALS	low income	medium income	-1.2263	1.4376	0.829	-4.960	2.507
		high income	-1.1061	1.5957	0.900	-5.250	3.038
		unspecified	-0.0167	1.8080	1.000	-4.712	4.679

	medium income	low income	1.2263	1.4376	0.829	-2.507	4.960
		high income	0.1202	1.4135	1.000	-3.551	3.791
		unspecified	1.2097	1.6494	0.884	-3.074	5.493
	high income	low income	1.1061	1.5957	0.900	-3.038	5.250
		medium income	-0.1202	1.4135	1.000	-3.791	3.551
		unspecified	1.0895	1.7889	0.929	-3.556	5.735
	unspecified	low income	0.0167	1.8080	1.000	-4.679	4.712
		medium income	-1.2097	1.6494	0.884	-5.493	3.074
		high income	-1.0895	1.7889	0.929	-5.735	3.556
PUTRISCIBLES	low income	medium income	-1.3698	4.2464	0.988	-12.397	9.658
		high income	0.4955	4.7133	1.000	-11.745	12.736
		unspecified	16.6131*	5.3404	0.012	2.744	30.482
	medium income	low income	1.3698	4.2464	0.988	-9.658	12.397
		high income	1.8653	4.1751	0.970	-8.977	12.708
		unspecified	17.9828*	4.8719	0.002	5.331	30.635
	high income	low income	-0.4955	4.7133	1.000	-12.736	11.745
		medium income	-1.8653	4.1751	0.970	-12.708	8.977
		unspecified	16.1175*	5.2839	0.014	2.396	29.839
	unspecified	low income	-16.6131*	5.3404	0.012	-30.482	-2.744
		medium income	-17.9828*	4.8719	0.002	-30.635	-5.331
		high income	-16.1175*	5.2839	0.014	-29.839	-2.396

TEXTILES	low income	medium income	0.7202	0.8974	0.853	-1.610	3.051
		high income	1.0719	0.9961	0.705	-1.515	3.659
		unspecified	1.3958	1.1286	0.604	-1.535	4.327
	medium income	low income	-0.7202	0.8974	0.853	-3.051	1.610
		high income	0.3517	0.8824	0.978	-1.940	2.643
		unspecified	0.6756	1.0296	0.913	-1.998	3.350
	high income	low income	-1.0719	0.9961	0.705	-3.659	1.515
		medium income	-0.3517	0.8824	0.978	-2.643	1.940
		unspecified	0.3239	1.1167	0.991	-2.576	3.224
	unspecified	low income	-1.3958	1.1286	0.604	-4.327	1.535
		medium income	-0.6756	1.0296	0.913	-3.350	1.998
		high income	-0.3239	1.1167	0.991	-3.224	2.576
MISC-COMBUSTIBLES	low income	medium income	-0.6514	1.5413	0.975	-4.654	3.351
		high income	0.6384	1.7108	0.982	-3.804	5.081
		unspecified	-0.5561	1.9384	0.992	-5.590	4.478
	medium income	low income	0.6514	1.5413	0.975	-3.351	4.654
		high income	1.2898	1.5154	0.830	-2.646	5.225
		unspecified	0.0953	1.7683	1.000	-4.497	4.688
	high income	low income	-.06384	1.7108	0.982	-5.081	3.804
		medium income	-1.2898	1.5154	0.830	-5.225	2.646
		unspecified	-1.1945	1.9179	0.925	-6.175	3.786

	unspecified	low income	0.5561	1.9384	0.992	-4.478	5.590
		medium income	-0.0953	1.7683	1.000	-4.688	4.497
		high income	1.1945	1.9179	0.925	-3.786	6.175
MISC NON-COMBUSTIBLES	low income	medium income	0.9147	1.2323	0.880	-2.286	4.115
		high income	0.5638	1.3679	0.976	-2.988	4.116
		unspecified	0.7719	1.5498	0.959	-3.253	4.797
	medium income	low income	-0.9147	1.2323	0.880	-4.115	2.286
		high income	-0.3509	1.2117	0.992	-3.497	2.796
		unspecified	-0.1428	1.4139	1.000	-3.815	3.529
	high income	low income	-0.5638	1.3679	0.976	-4.116	2.988
		medium income	0.3509	1.2117	0.992	-2.796	3.497
		unspecified	0.2081	1.5334	0.999	-3.774	4.190
	unspecified	low income	-0.7719	1.5498	0.959	-4.797	3.253
		medium income	0.1428	1.4139	1.000	-3.529	3.815
		high income	-0.2081	1.5334	0.999	-4.190	3.774
WEE	low income	medium income	-0.6995	0.7626	0.796	-2.680	1.281
		high income	-0.2564	0.8465	0.990	-2.455	1.942
		unspecified	-2.1181	0.9591	0.125	-4.609	0.373
	medium income	low income	0.6995	0.7626	0.796	-1.281	2.680
		high income	0.4430	0.7498	0.935	-1.504	2.390
		unspecified	-1.4186	0.8750	0.370	-3.691	0.854

	high income	low income	0.2564	0.8465	0.990	-1.942	2.455
		medium income	-0.4430	0.7498	0.935	-2.390	1.504
		unspecified	-1.8616	0.9490	0.207	-4.326	0.603
	unspecified	low income	2.1181	0.9591	0.125	-0.373	4.609
		medium income	1.4186	0.8750	0.370	-0.854	3.691
		high income	1.8616	0.9490	0.207	-0.603	4.326
HHW	low income	medium income	0.1072	0.0836	0.576	-0.110	0.324
		high income	0.1082	0.0928	0.649	-0.133	0.349
		unspecified	0.0181	0.1051	0.998	-0.255	0.291
	medium income	low income	-0.1072	0.0836	0.576	-0.324	0.110
		high income	0.0010	0.0822	1.000	-0.212	0.214
		unspecified	-0.0891	0.0959	0.789	-0.338	0.160
	high income	low income	-0.1082	0.0928	0.649	-0.349	0.133
		medium income	-0.0010	0.0822	1.000	-0.214	0.212
		unspecified	-0.0901	0.1040	0.822	-0.360	0.180
	unspecified	low income	-0.0181	0.1051	0.998	-0.291	0.255
		medium income	0.0891	0.0959	0.789	-0.160	0.338
		high income	0.0901	0.1040	0.822	-0.180	0.360
FINE ELEMENTS	low income	medium income	-1.0967	2.2009	0.959	-6.812	4.619
		high income	-0.6617	2.4429	0.993	-7.006	5.682
		unspecified	-0.5181	2.7679	0.998	-7.706	6.670

	medium income	low income	1.0967	2.2009	0.959	-4.619	6.812
		high income	0.4350	2.1639	0.997	-5.185	6.055
		unspecified	0.5787	2.5251	0.996	-5.979	7.136
	high income	low income	0.6617	2.4429	0.993	-5.682	7.006
		medium income	-0.4350	2.1639	0.997	-6.055	5.185
		unspecified	0.1436	2.7386	1.000	-6.968	7.256
	unspecified	low income	0.5181	2.7679	0.998	-6.670	7.706
		medium income	-0.5787	2.5251	0.996	-7.136	5.979
		high income	-0.1436	2.7386	1.000	-7.256	6.968

*. The mean difference is significant at the 0.05 level.

Appendix 9: Tests of Between-Subjects Effects (Analysis of variance of barriers)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Policies lack clear strategies	14.252[a]	2	7.126	1.825	0.162
	Legal framework is weak*	34.275[b]	2	17.138	4.263	0.014
	Waste institutions*	110.961[c]	2	55.481	14.354	<0.001
	Unplanned city aspects	5.026[d]	2	2.513	.539	.583
	Waste has high density & Moisture content	13.528[e]	2	6.764	1.663	0.190
	Availability of dumping grounds*	68.605[f]	2	34.303	7.647	<0.001
	Funding limitations*	176.121[g]	2	88.060	19.817	<0.001
	Low level public education on waste mgt*	48.653[h]	2	24.327	5.984	0.003
	Waste workers poorly paid & trained*	76.740[i]	2	38.370	7.892	<0.001
	Obsolete and insufficient operational equipment	9.336[j]	2	4.668	1.078	0.341
Intercept	Policies lack clear strategies	7697.486	1	7697.486	1971.723	<0.001
	Legal framework is weak	8274.863	1	8274.863	2058.575	<0.001
	Waste institutions*	8536.153	1	8536.153	2208.516	<0.001
	Unplanned city aspects*	8613.359	1	8613.359	1848.225	<0.001
	Waste has high density & moisture content*	6925.459	1	6925.459	1702.550	<0.001
	Availability of dumping grounds*	7301.258	1	7301.258	1627.622	<0.001
	Funding limitations*	10617.736	1	10617.736	2389.355	<0.001
	Low level public education on waste mgt*	13118.836	1	13118.836	3227.009	<0.001
	Waste workers poorly paid & trained*	12392.161	1	12392.161	2548.702	<0.001
	Obsolete and insufficient operational equipment*	12665.330	1	12665.330	2924.867	<0.001
Respondent	Policies lack clear strategies	14.252	2	7.126	1.825	0.162
	Legal framework is weak*	34.275	2	17.138	4.263	0.014
	Waste institutions*	110.961	2	55.481	14.354	<0.001
	Unplanned city aspects	5.026	2	2.513	0.539	0.583

	Waste has high density & moisture content	13.528	2	6.764	1.663	0.190
	Availability of dumping grounds*	68.605	2	34.303	7.647	<0.001
	Funding limitations*	176.121	2	88.060	19.817	<0.001
	Low level public education on waste mgt*	48.653	2	24.327	5.984	0.003
	Waste workers poorly paid & trained*	76.740	2	38.370	7.892	<0.001
	Obsolete and insufficient operational equipment	9.336	2	4.668	1.078	0.341
Error	Policies lack clear strategies	5723.174	1466	3.904		
	Legal framework is weak	5892.886	1466	4.020		
	Waste institutions	5666.249	1466	3.865		
	Unplanned city aspects	6832.060	1466	4.660		
	Waste has high density & Moisture content	5963.244	1466	4.068		
	Availability of dumping grounds	6576.247	1466	4.486		
	Funding limitations	6514.561	1466	4.444		
	Low level public education on waste mgt	5959.765	1466	4.065		
	Waste workers poorly paid & trained	7127.905	1466	4.862		
	Obsolete and insufficient operational equipment	6348.109	1466	4.330		
Total	Policies lack clear strategies	23091.000	1469			
	Legal framework is weak	24469.000	1469			
	Waste institutions	26527.000	1469			
	Unplanned city aspects	24724.000	1469			
	Waste has high density & moisture content	21851.000	1469			
	Availability of dumping grounds	23016.000	1469			
	Funding limitations	29844.000	1469			

	Low level public education on waste mgt	35178.000	1469			
	Waste workers poorly paid & trained	31965.000	1469			
	Obsolete and insufficient operational equipment	32694.000	1469			
Corrected Total	Policies lack clear strategies	5737.425	1468			
	Legal framework is weak	5927.161	1468			
	Waste institutions	5777.210	1468			
	Unplanned city aspects	6837.086	1468			
	Waste has high density & moisture content	5976.772	1468			
	Availability of dumping grounds	6644.852	1468			
	Funding limitations	6690.682	1468			
	Low level public education on waste mgt	6008.418	1468			
	Waste workers poorly paid & trained	7204.645	1468			
	Obsolete and insufficient operational equipment	6357.445	1468			

*. The mean difference is significant at the 0.05 level
a. R Squared = 0.002 (Adjusted R Squared = 0.001)
b. R Squared = 0.006 (Adjusted R Squared = 0.004)
c. R Squared = 0.019 (Adjusted R Squared = 0.018)
d. R Squared = 0.001 (Adjusted R Squared = -0.001)
e. R Squared = 0.002 (Adjusted R Squared = 0.001)
f. R Squared = 0.010 (Adjusted R Squared =0 .009)
g. R Squared = 0.026 (Adjusted R Squared = 0.025)
h. R Squared = 0.008 (Adjusted R Squared = 0.007)
i. R Squared = .0011 (Adjusted R Squared = 0.009)
j. R Squared = 0.001 (Adjusted R Squared =<0.001).

Appendix 10: Post-hoc tests (multiple comparisons of variance barriers)

Dependent Variable	(I) type of respondent	(J) type of respondent	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Boundary	Upper Boundary
Policies lack clear strategies	households	businesses	0.00	0.154	1.000	-0.36	0.36
		policymakers	0.33	0.176	0.140	-0.08	0.75
	businesses	households	<0.001	0.154	1.000	-0.36	0.36
		policymakers	0.33	0.219	0.280	-0.18	0.85
	policymakers	households	-0.33	0.176	0.140	-0.75	0.08
		businesses	-0.33	0.219	0.280	-0.85	0.18
Legal framework is weak	households	businesses	-0.18	0.156	0.495	-0.54	0.19
		policymakers	0.45*	0.179	0.031	0.03	0.87
	businesses	households	0.18	0.156	0.495	-0.19	0.54
		policymakers	0.63*	0.222	0.013	0.11	1.15
	policymakers	households	-0.45*	0.179	0.031	-0.87	-0.03
		businesses	-0.63*	0.222	0.013	-1.15	-0.11
Waste institutions	households	businesses	<0.001	0.153	0.999	-0.36	0.36
		policymakers	0.93*	0.176	<0.001	0.52	1.35
	businesses	households	<0.001	0.153	.999	-0.36	0.36
		policymakers	0.93*	0.218	<0.001	0.42	1.44

	policymakers	households	-0.93*	0.176	<0.001	-1.35	-0.52
		businesses	-0.93*	0.218	<0.001	-1.44	-0.42
Unplanned city aspects	households	businesses	-0.10	0.168	0.831	-0.49	0.30
		policymakers	-0.18	0.193	0.623	-0.63	0.27
	businesses	households	0.10	0.168	0.831	-0.30	0.49
		policymakers	-0.08	0.239	0.939	-0.64	0.48
	policymakers	households	0.18	0.193	0.623	-0.27	0.63
		businesses	0.08	0.239	0.939	-0.48	0.64
Waste has high density & moisture content	households	businesses	0.21	0.157	0.381	-0.16	0.58
		policymakers	0.25	0.180	0.336	-0.17	0.68
	businesses	households	-0.21	0.157	0.381	-0.58	0.16
		policymakers	0.05	0.224	0.978	-0.48	0.57
	policymakers	households	-0.25	0.180	0.336	-0.68	0.17
		businesses	-0.05	0.224	0.978	-0.57	0.48
Availability of dumping grounds	households	businesses	-0.34	0.165	0.102	-0.73	0.05
		policymakers	0.58*	0.189	0.007	0.13	1.02
	businesses	households	0.34	0.165	0.102	-0.05	0.73
		policymakers	0.91*	0.235	<0.001	0.36	1.47
	policymakers	households	-0.58*	0.189	0.007	-1.02	-0.13
		businesses	-0.91*	0.235	<0.001	-1.47	-0.36
Funding limitations	households	businesses	-0.73*	0.164	<0.001	-1.11	-0.34

		policymakers	0.73*	0.188	<0.001	0.29	1.17
	businesses	households	0.73*	0.164	<0.001	0.34	1.11
		policymakers	1.46*	0.234	<0.001	0.91	2.01
	policymakers	households	-0.73*	0.188	<0.001	-1.17	-0.29
		businesses	-1.46*	0.234	<0.001	-2.01	-0.91
Low level public education on waste mgt	households	businesses	-0.25	0.157	0.264	-0.61	0.12
		policymakers	0.52*	0.180	0.012	0.09	0.94
	businesses	households	0.25	0.157	0.264	-0.12	0.61
		policymakers	0.76*	0.224	0.002	0.24	1.29
	policymakers	households	-0.52*	0.180	0.012	-0.94	-0.09
		businesses	-0.76*	0.224	0.002	-1.29	-0.24
Waste workers poorly paid & trained	households	businesses	-0.68*	0.172	<0.001	-1.09	-0.28
		policymakers	-0.07	0.197	0.936	-0.53	0.39
	businesses	households	0.68*	0.172	<0.001	0.28	1.09
		policymakers	0.61*	0.245	0.032	0.04	1.19
	policymakers	households	0.07	0.197	0.936	-0.39	0.53
		businesses	-0.61*	0.245	0.032	-1.19	-0.04
Obsolete and insufficient operational equipment	households	businesses	-0.23	0.162	0.338	-0.61	0.15
		policymakers	-0.11	0.186	0.821	-0.55	0.32
	businesses	households	0.23	0.162	0.338	-0.15	0.61
		policymakers	0.12	0.231	0.868	-0.42	0.66

	policymakers	households	0.11	0.186	0.821	-0.32	0.55
		businesses	-0.12	0.231	0.868	-0.66	0.42

Based on observed means. The error term is Mean Square (Error) = 4.330. *. The mean difference is significant at the 0.05 level.

Appendix

ANNEXE 3.7.1: LETTER OF INVITATION TO PARTICIPATE IN FOCUS GROUP DISCUSSION

To: **(see** list below)

<Date>

Dear **<Name>**

The University of Wolverhampton, United Kingdom will be conducting a Focus Group Discussion on municipal solid waste management in Abuja Nigeria on 15th September, 2008.

To assist in this work, the University will be consulting with residents of Abuja and other stakeholders, to understand current management practices and analyse the barriers and success factors affecting the adoption of sustainable management practices.
As part of this process, we have decided to invite a small group of local residents, waste workers, representatives of government institutions and civil society to an interactive forum

We would therefore like to invite you to take part in the discussion **at the Dayspring Hotel, Wuse zone 6, Abuja on September 19th 2008**. The discussion will **start at 2pm**, and finish around 5pm. Tea, coffee and light refreshments will be provided.

The discussion will be hosted by a researcher from the University with segments to be led by experts in the waste sector whose role is impartial. Your identity will remain anonymous and you will not be personally identified in any subsequent reports

Places are limited; therefore, we will contact you by telephone again during the week before to confirm your attendance. As a token of our appreciation, we would like to offer you a small hamper of local produce which will be handed out on the evening.

We are sure that the group will result in lively discussion, and will once more contribute to the enhancement and the enjoyment of your environment within Abuja.

If you have any queries regarding these discussions, then please contact …….

Thank you for your support, we look forward to seeing you again on Friday, 19 September.

Yours sincerely